NASA Trace Gas Products for Air Quality Applications

Part 1: NO_2 and SO_2

NASA Remote Sensing Training

Webinar 5: February 2014

ARSET

Applied Remote SEnsing Training

A project of NASA Applied Sciences

Outline for Week 5 Presentation – Part 1

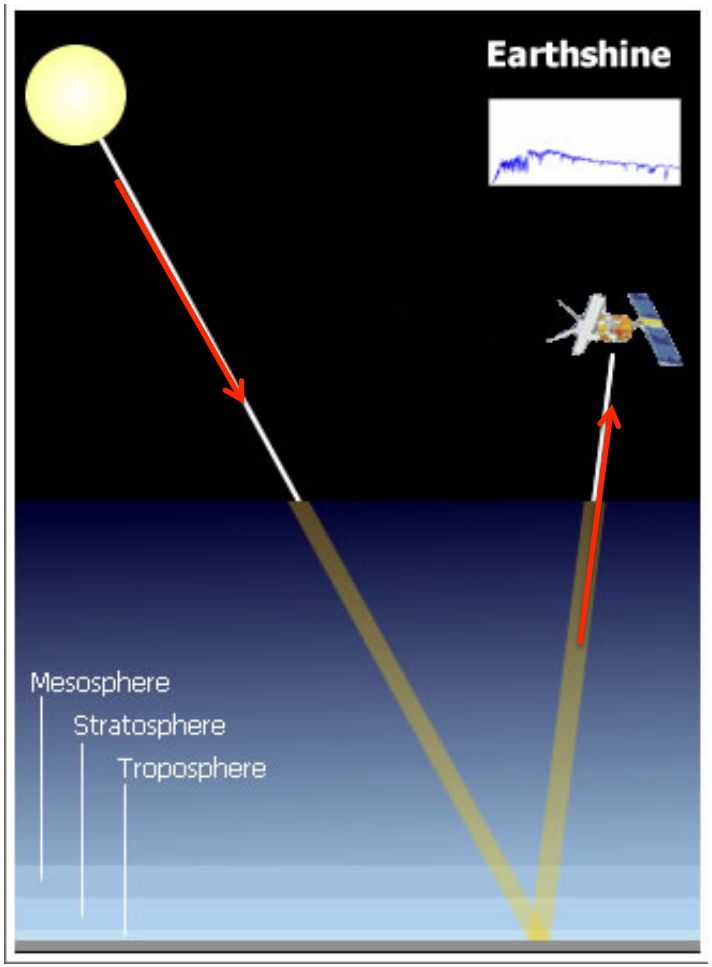
1. Background information on trace gas detection and products.
2. A tour of Aura trace gas products and some applications: What is available/applicable for AQ studies?

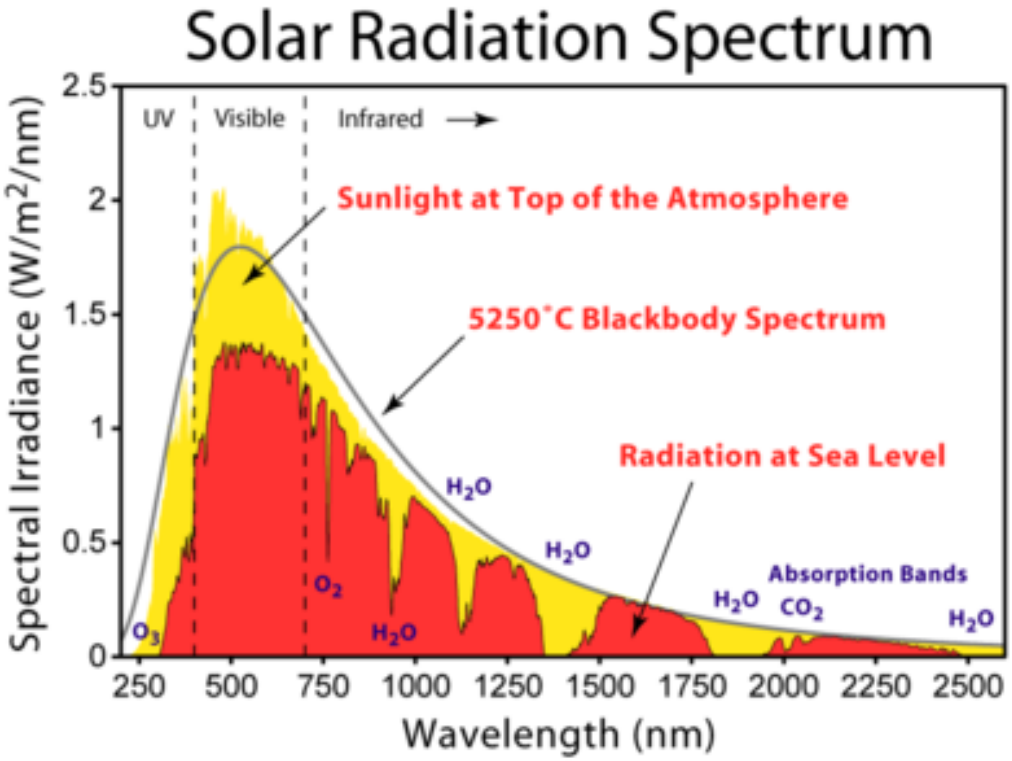
OMI – Ozone Monitoring Instrument

- Tropospheric Column NO_2 [molecules/cm^2]
- PBL, Volcanic SO_2 [Dobson Units – DU]

Part 2 will cover CO from AIRS and MOPITT – pollution and trace gas fire product

How Satellites Measure Trace Gases

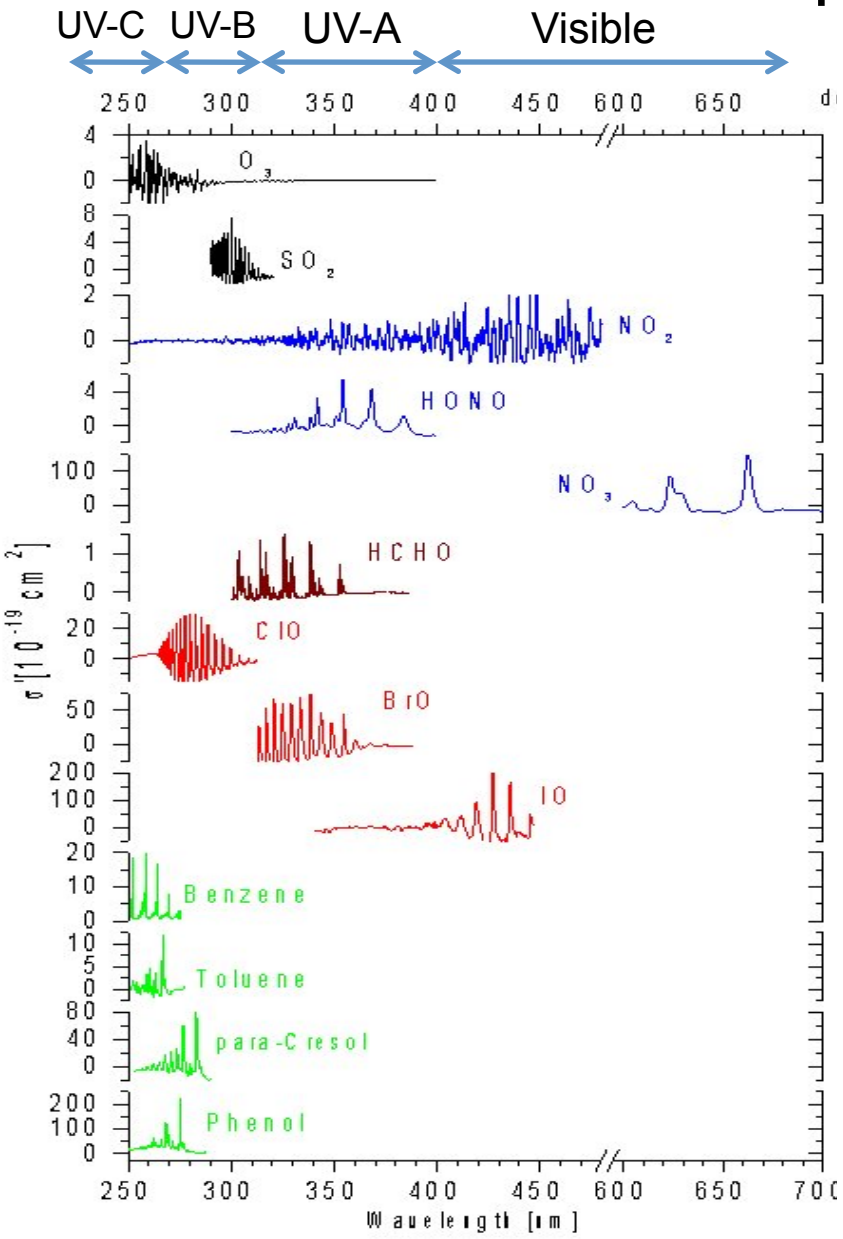


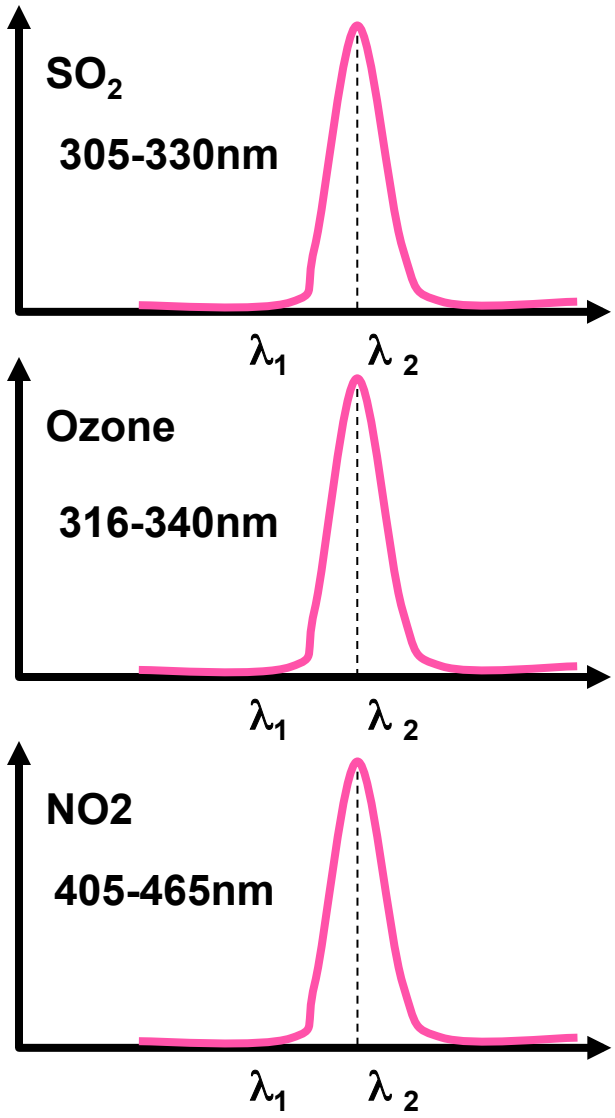


Unlike remote sensing of aerosols that use the signature of aerosol scattering, remote sensing of trace gases uses the signature of gas absorption.

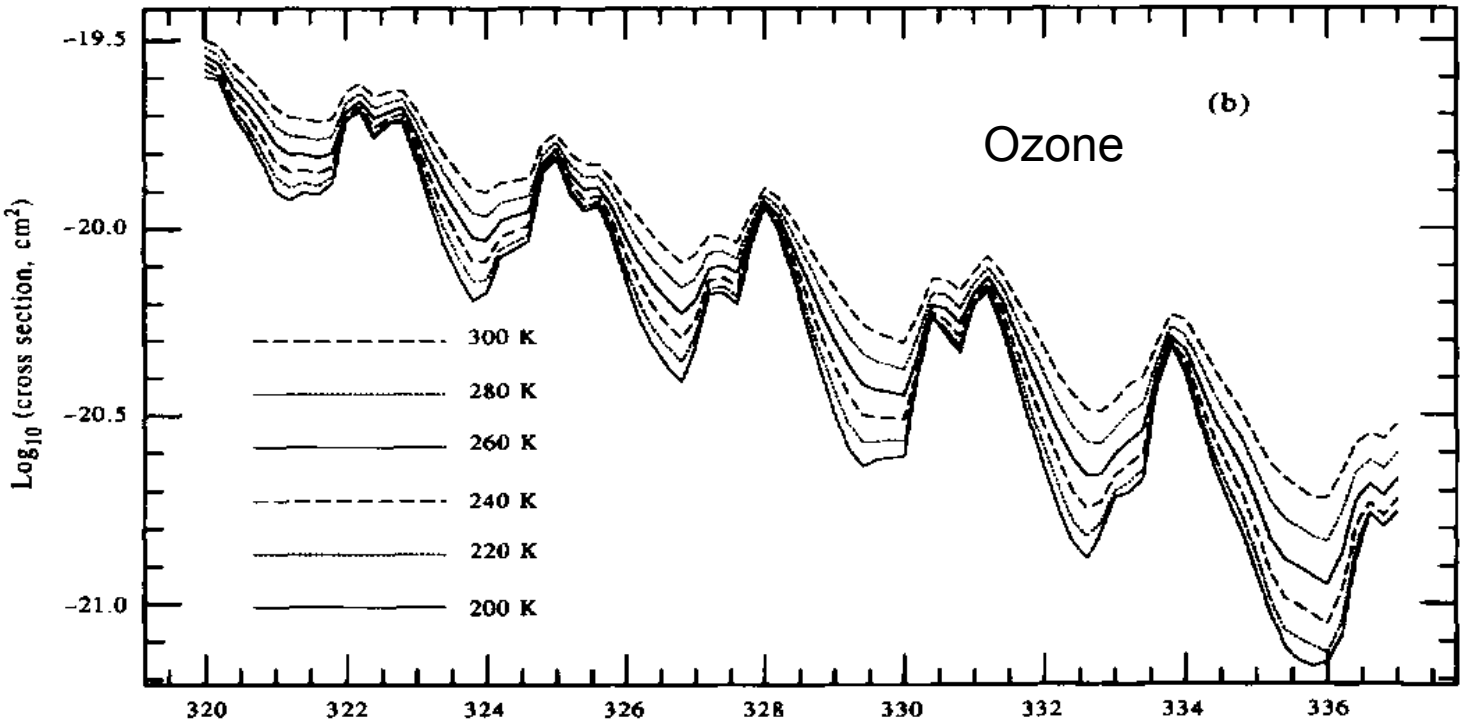
All satellite remote sensing measurements of the troposphere are based on the use of electromagnetic radiation and its interaction with constituents in the atmosphere.

Satellite measurements take advantage of distinct absorption spectra



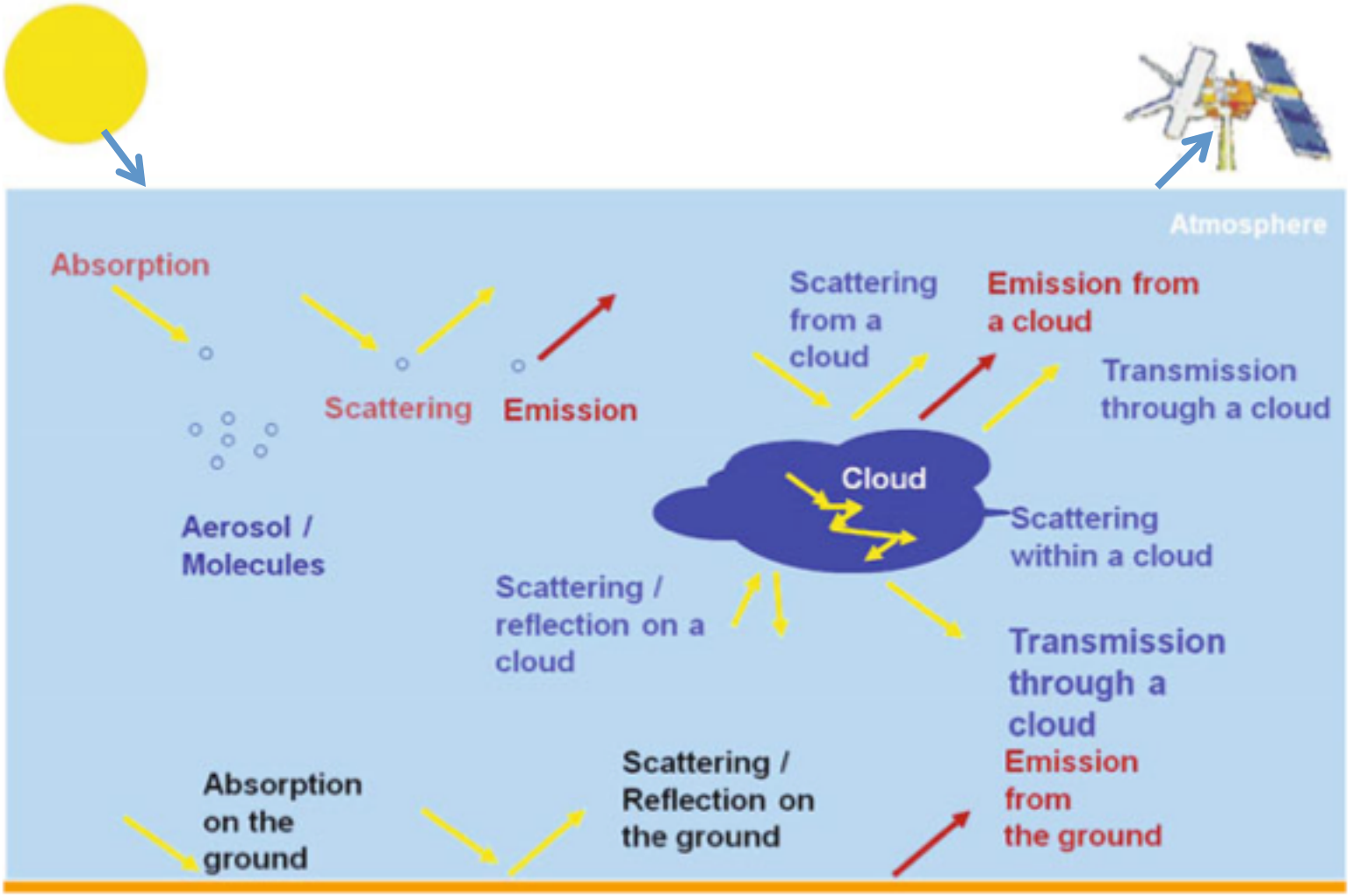


The characteristics of absorption spectra of trace gases will also depend on pressure/temperature or altitude.



The sensitivity to different levels in the troposphere also needs to be taken into account.

The next slide shows the different processes in radiative transfer through the atmosphere.



Schematic of the most important processes affecting the radiative transport through the atmosphere.

Depending on the wavelength range of absorption for a particular trace gas, the sensitivity to different layers in the troposphere varies and needs to be taken into account when interpreting the results.

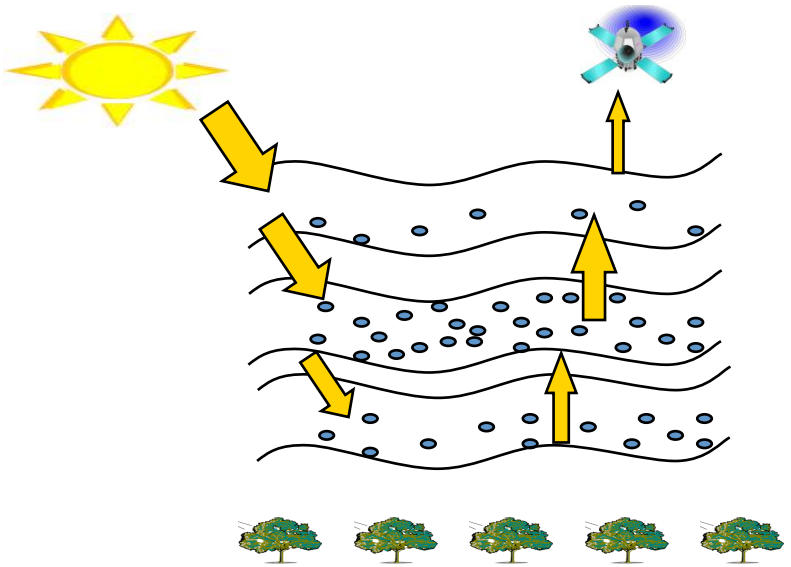
Something to consider for satellite observations

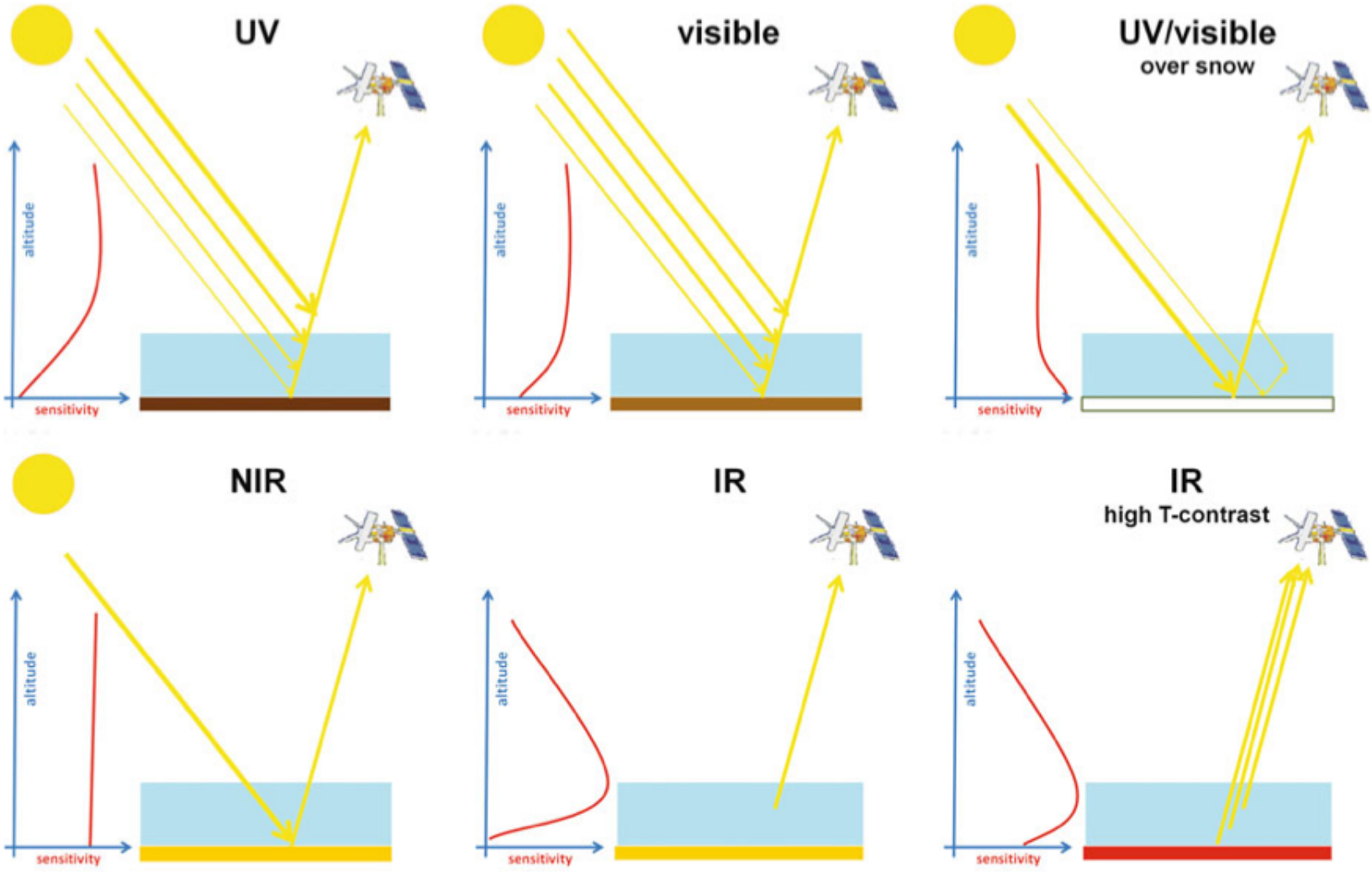
Vertical Resolution

In the UV and visible part of the spectrum (O_3, SO_2 and NO_2 relevant), the measurements contain very little information on the vertical distribution of the species, usually providing just one piece of information (the tropospheric column amount).

Observations at different wavelengths (technique of combining UV, visible, and IR measurements) contains some vertical information

i.e. the penetration depth of photons increases towards longer wavelengths, and for volcanic plumes of SO2, this has already been exploited.

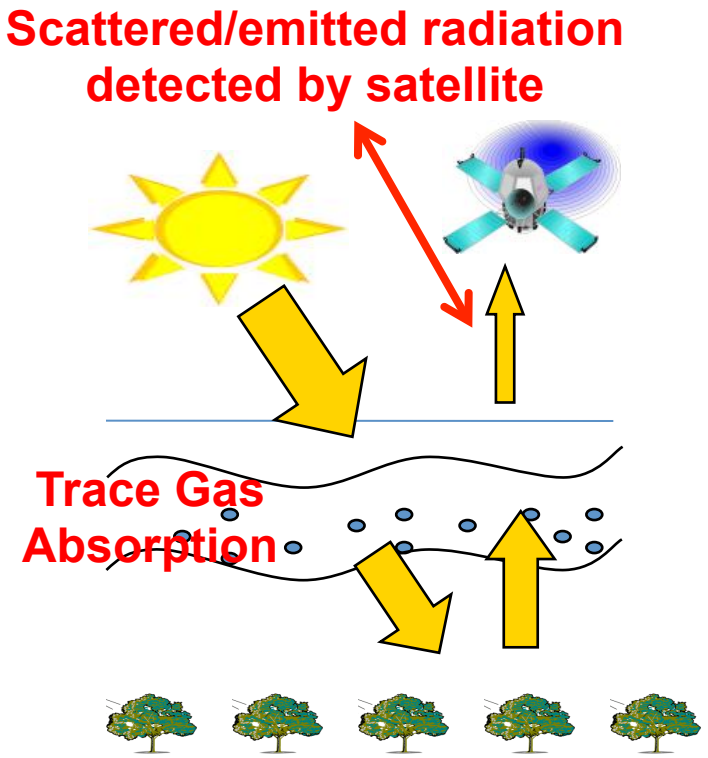




Sketch of measurement geometry and vertical sensitivity for satellite observations of the troposphere in different wavelength ranges.

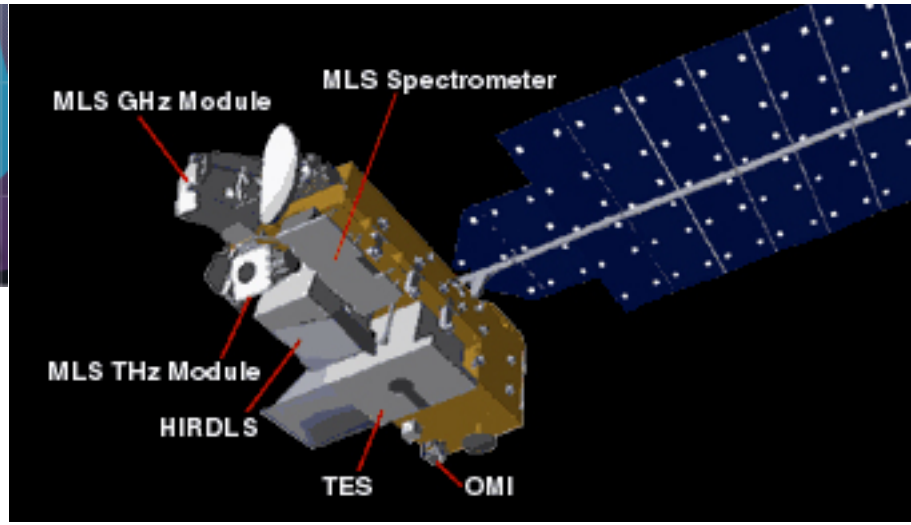
To summarize …

1. Satellites detect backscattered solar radiation and/or emitted thermal radiation
2. We know the distinct absorption spectra of each trace gases.
3. By knowing how and by what amount different molecules absorb radiation at different wavelengths, we can identify a "fingerprint" for each atmospheric constituent.
4. Based on the radiation measured by the instrument, retrieval algorithms are used to infer physical measurements (such as number density, partial pressure, column amount) of the different gases.



AQ Measurements from Space: What is available?

http://aura.gsfc.nasa.gov



OMI – Ozone Monitoring Instrument

- Tropospheric Column NO_2 [molecules/cm^3]
- PBL, Volcanic SO_2 [Dobson Units - DU]

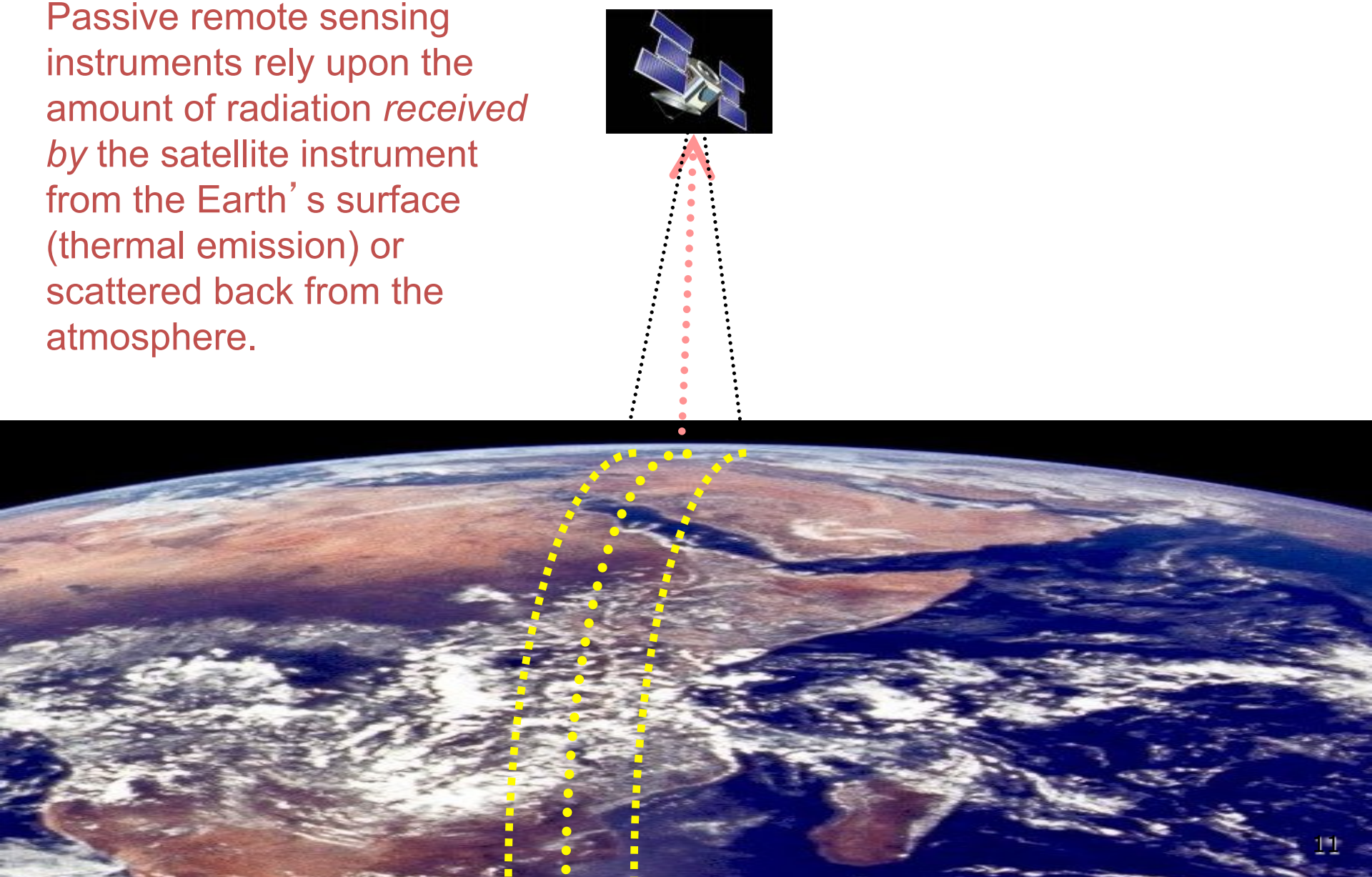
~~**TES – Tropospheric Emission Spectrometer**~~

- ~~Vertical profiles of Ozone and CO~~

TES is no longer taking global measurements.

OMI, TES, AIRS, to name a few, are a class of Passive Remote Sensing Instruments

Passive remote sensing instruments rely upon the amount of radiation *received by* the satellite instrument from the Earth's surface (thermal emission) or scattered back from the atmosphere.



Aura (Aqua and Terra) are Polar Orbiting Satellites

The nadir **Field of View (FOV)** is defined as directly beneath the satellite track, when the satellite is overhead (90° elevation angle from the horizon).

Direction of Satellite Motion

Nadir

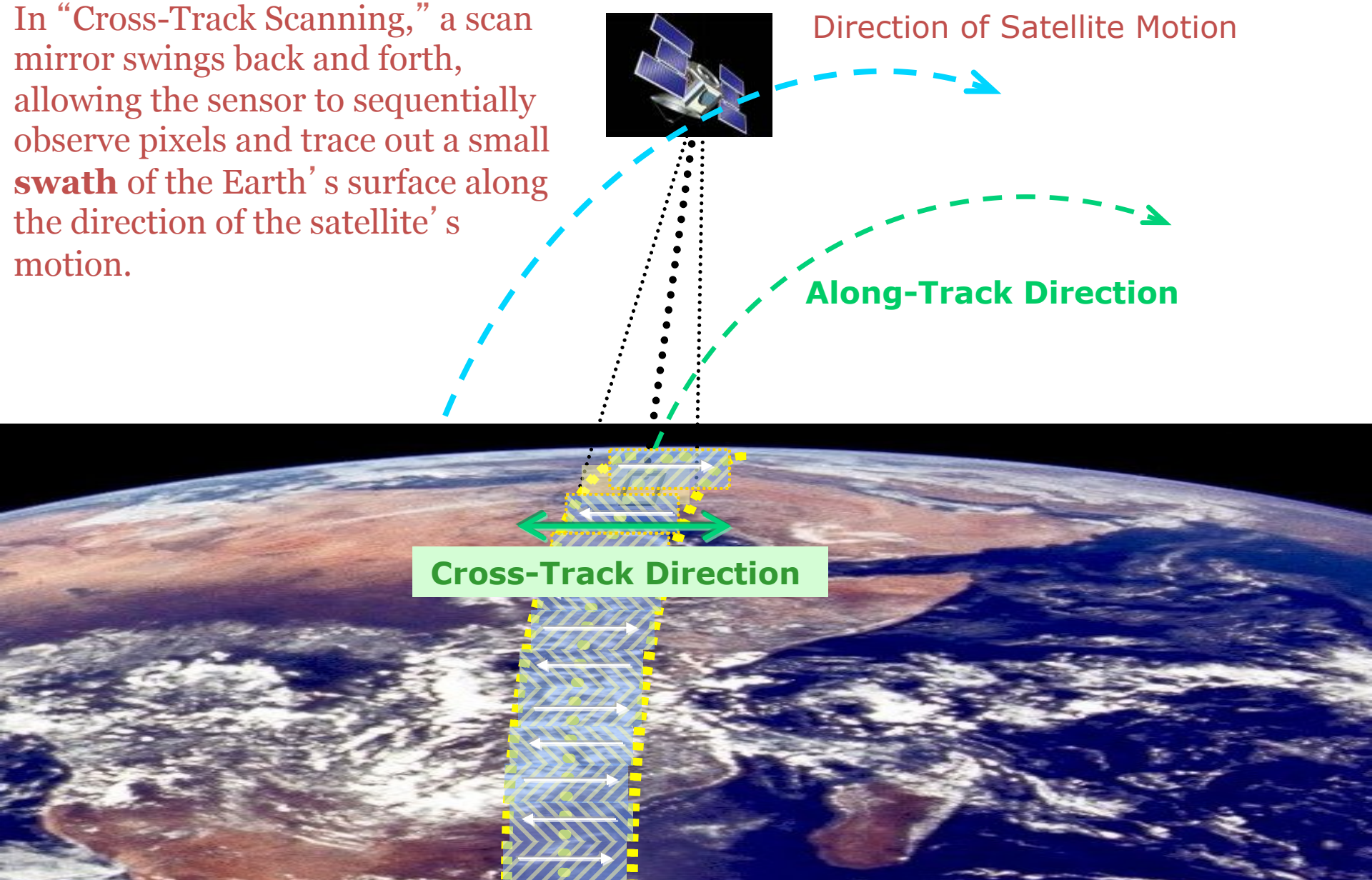
90°

Footprint or **pixel** is a geometric shape on the surface of the Earth (*i.e.*, 13×24 km² at nadir for OMI).

Horizon

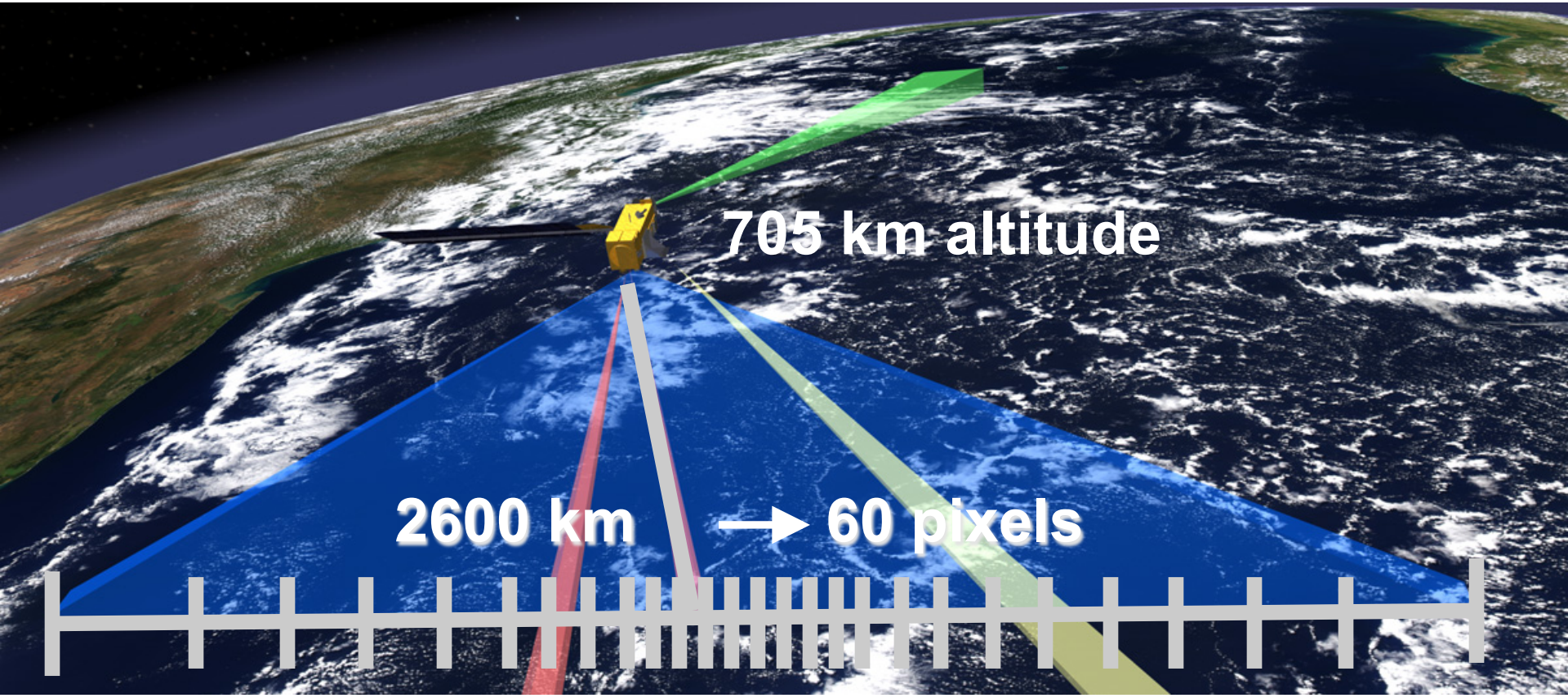
Trace gas instruments are Cross-Track Scanning Sensors

In "Cross-Track Scanning," a scan mirror swings back and forth, allowing the sensor to sequentially observe pixels and trace out a small **swath** of the Earth's surface along the direction of the satellite's motion.



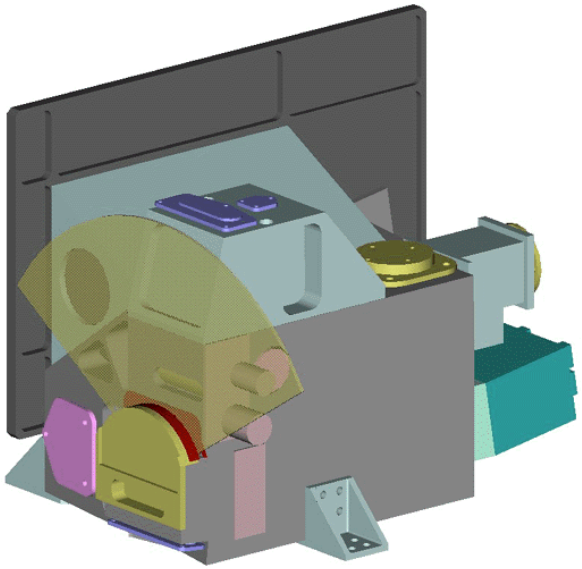
OMI Ozone Monitoring Instrument

- Dutch/Finnish Instrument
- Launched July 15, 2004
- Nadir solar backscatter spectrometer
- Spectral range UV/Visible 270-500 nm (resolution~0.5nm)
- Spatial resolution: 13X24 km footprint at nadir
- Swath width: 2600 km (global daily coverage)
- Local Overpass time = 13:45 (+/- 15 min)

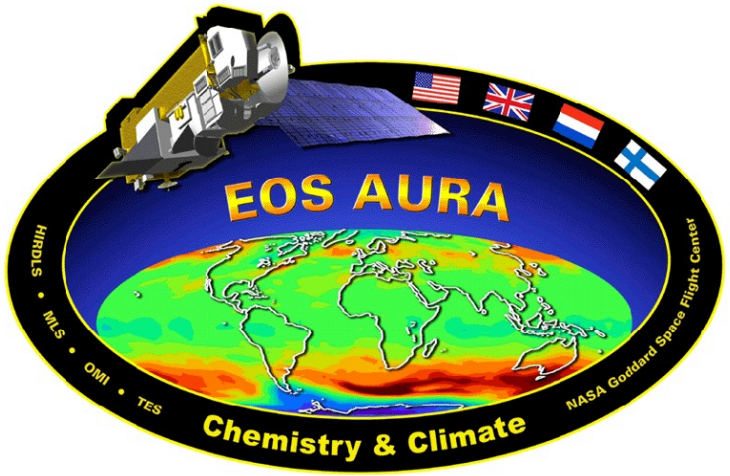


13 × 24 km at nadir **13 × 128 km^2 at the edges**

OMI Ozone Monitoring Instrument

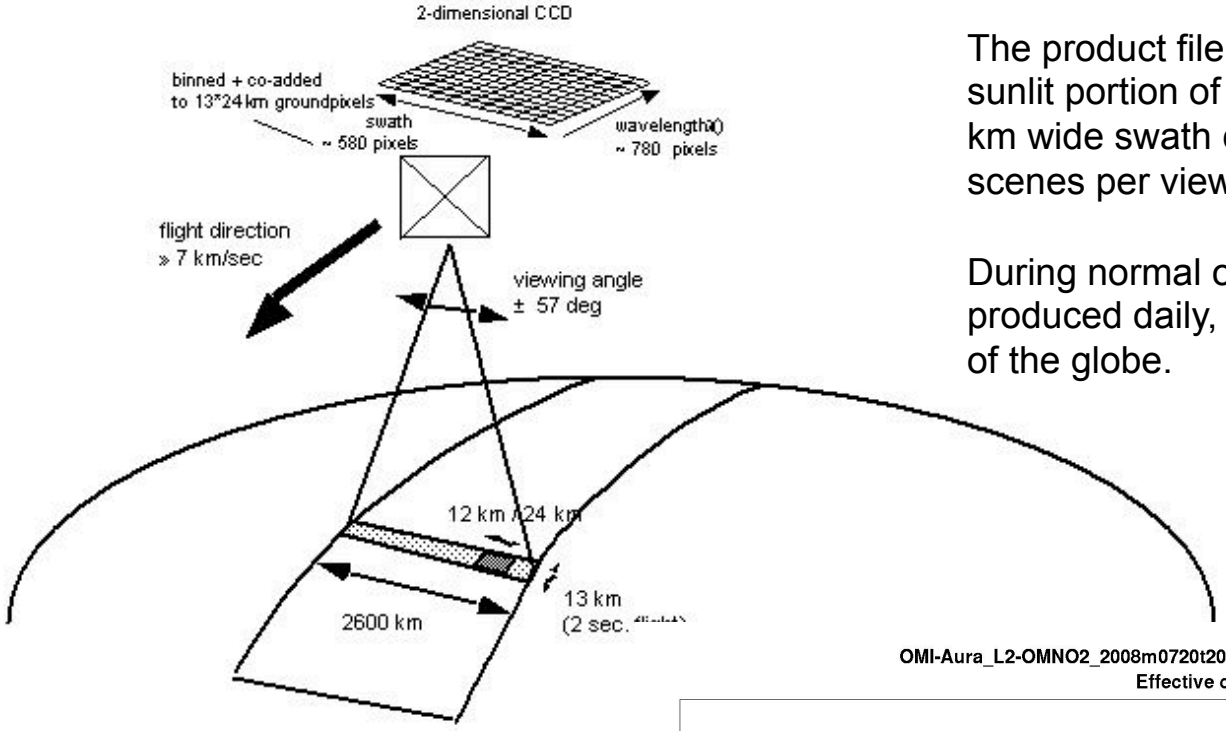


- Launched on July 15, 2004 on the NASA EOS Aura Satellite
- Nadir-viewing UV/Visible
  - 270-310 nm @ 0.6 nm
  - 310-500 nm @ 0.45 nm
- 1:40 PM equatorial crossing time
- 13x24 km^2 at nadir
- Daily global coverage.



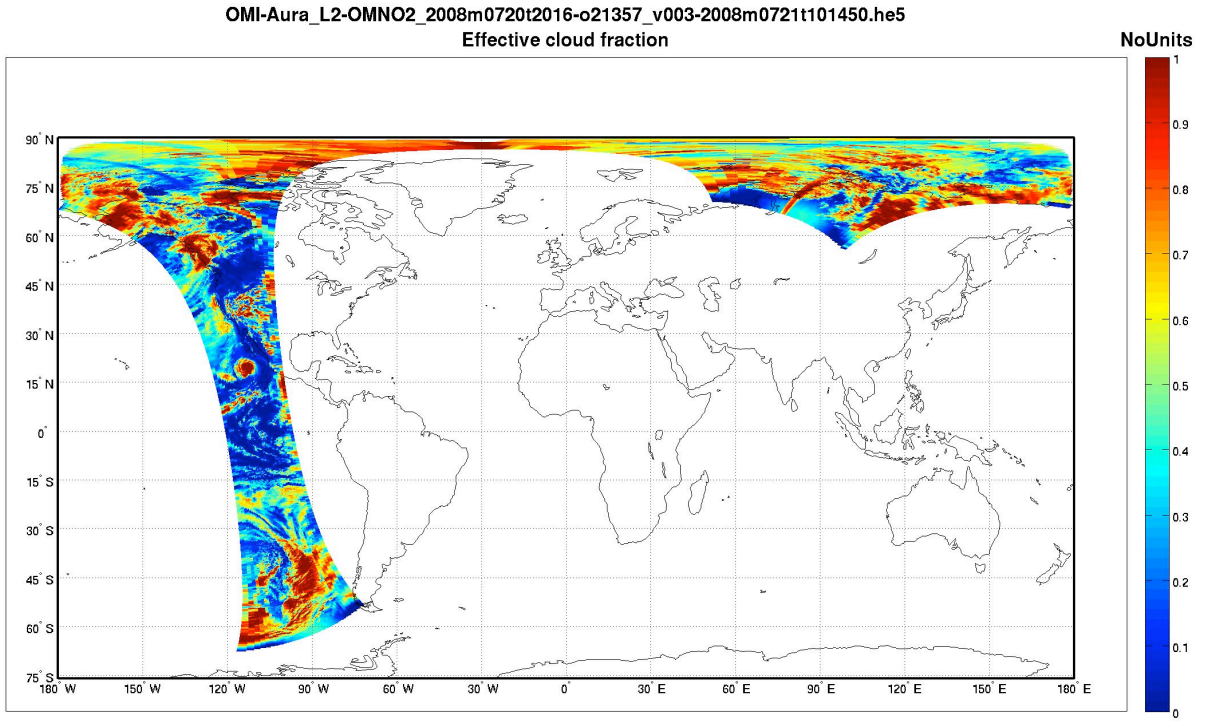
Products:

Total Column O_3
Tropospheric Column O_3 (experimental
But not applicable in the mid-latitudes)
Aerosol optical depth (in UV)
Column NO_2
Column SO_2

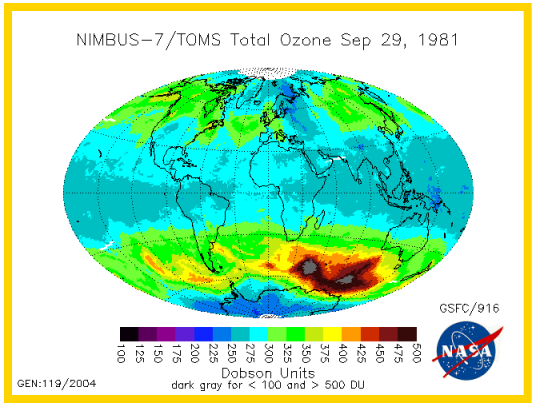


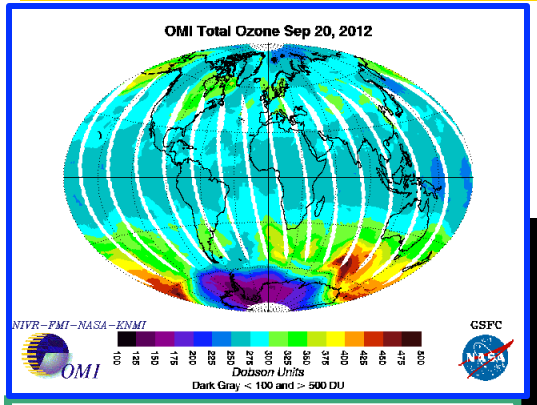
The product file, called a **data granule**, covers the sunlit portion of the orbit with an approximately 2600 km wide swath containing 60 binned pixels or scenes per viewing line.

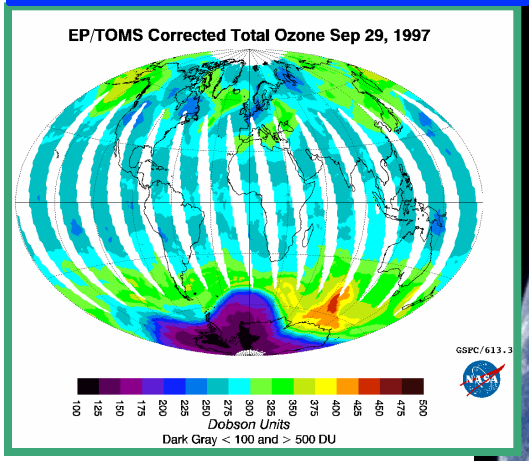
During normal operations, 14 or 15 granules are produced daily, providing fully contiguous coverage of the globe.



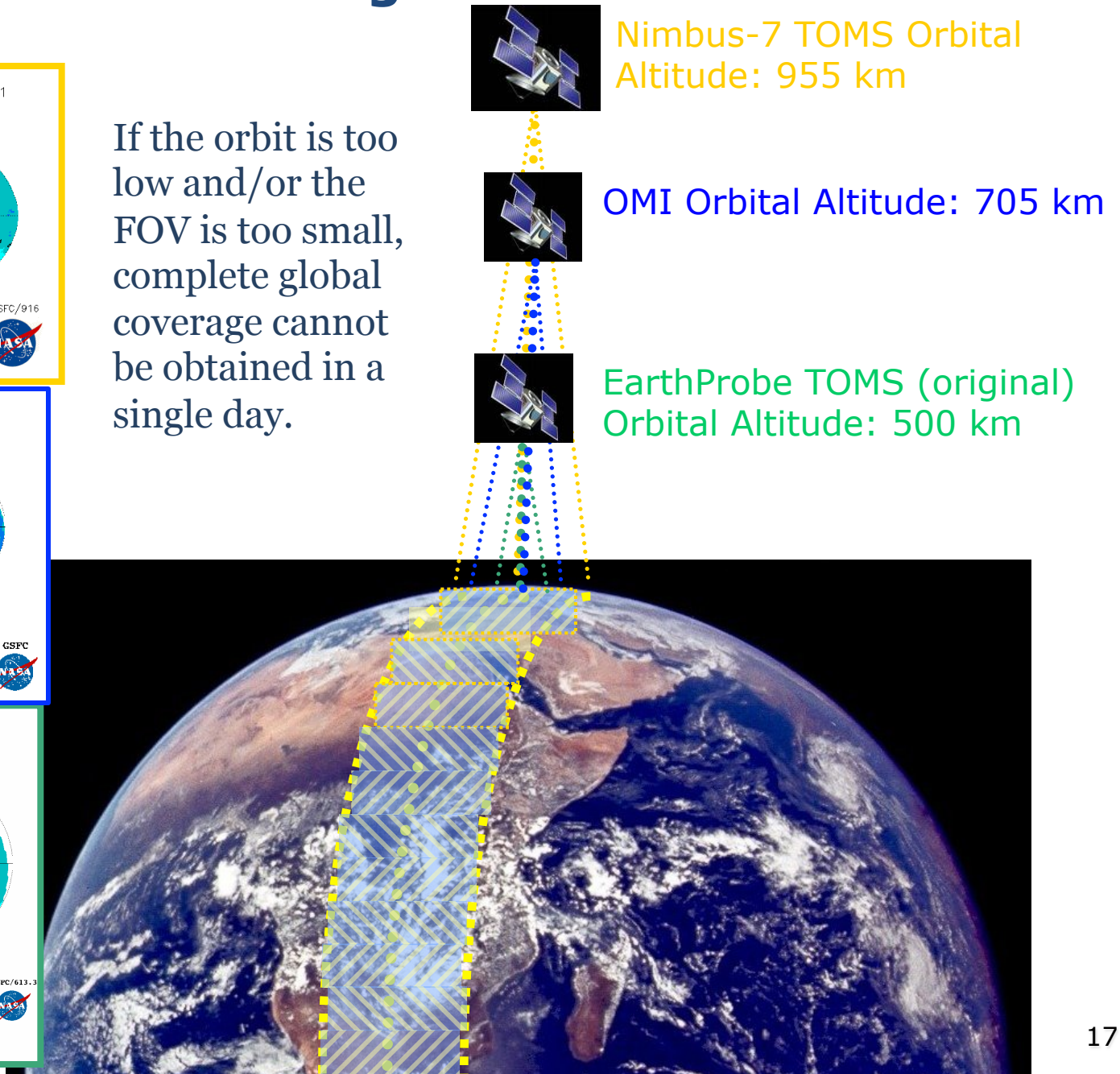
Spatial Coverage







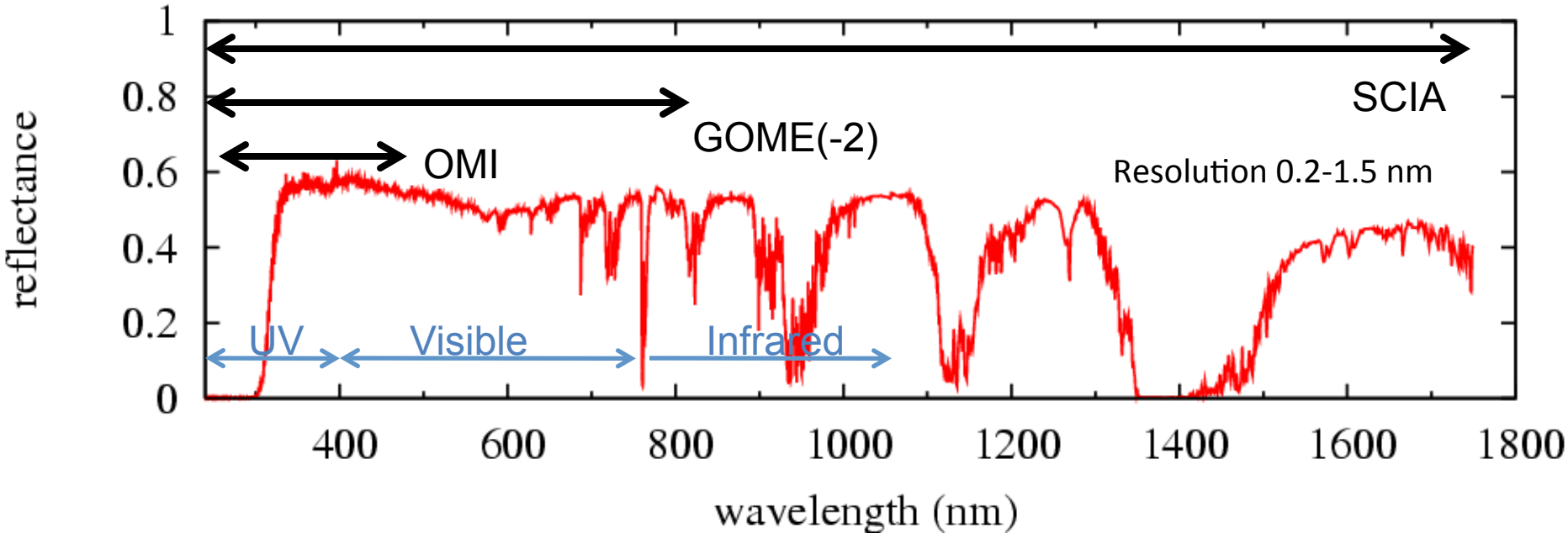
If the orbit is too low and/or the FOV is too small, complete global coverage cannot be obtained in a single day.



Hyper-spectral Instruments

Satellite UV-visible spectrometers

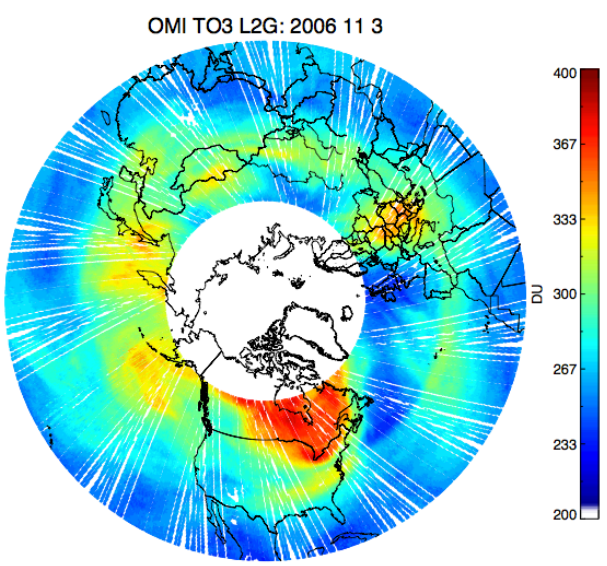
• GOME	ERS-2	240 – 800 nm
• SCIAMACHY	Envisat	240 – 1750 nm
• OMI	EOS-Aura	270 - 500 nm
• GOME-2	Metop-A	240 – 800 nm

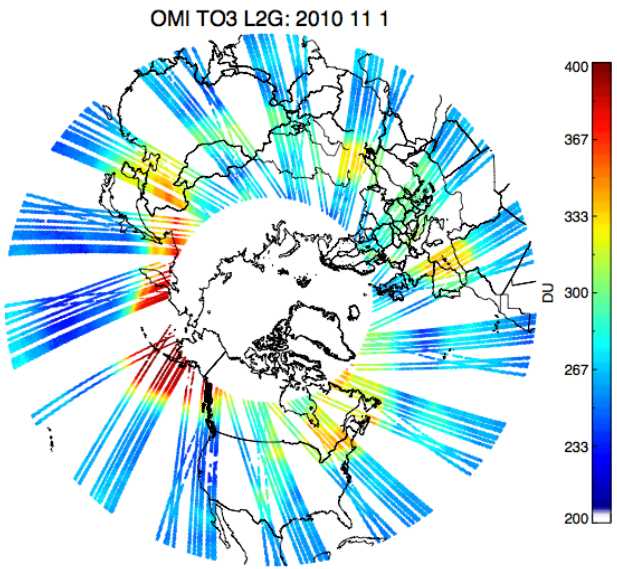


Important information regarding OMI

Almost 50% data loss since 2008
(row anomaly effect)

Affects O_3, SO_2, and to some extent NO_2 OMI Products





A word about OMI Ozone in the Troposphere

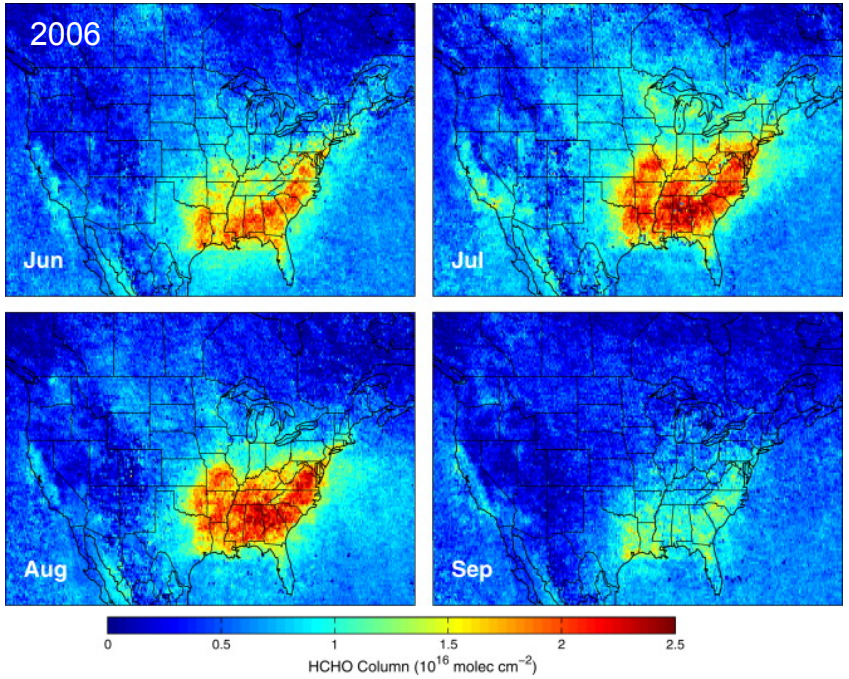
OMI is NOT sensitive to ozone near the surface. There are tropospheric ozone products in development but it currently cannot be used for AQ monitoring.

Retrieval of boundary layer O_3 from satellite remote sensing remains a daunting task.

A word about OMI Formaldehyde (HCHO, also written as CH_2O)

Data is reliable for the 2004-2009 time period only. Data re-processing is planned to account for the growing background noise and row anomalies.

HCHO is a proxy for isoprene emissions.



Source: Randall Martin, Satellite remote sensing of surface air quality, Atmos. Environ. 42(34), 7823-4843, 2008.

Quantification of gas abundances

Satellite Tracer	Units
OMI O_3, SO_2	Dobson Units
OMI NO_2 Column Amounts (also AIRS and MOPITT CO)	Molecules/cm^2
AIRS and MOPITT CO Vertical Levels	Volume mixing ratio

Dobson Unit – Typical Unit for measuring COLUMN burden of gases

A *Dobson* Unit is the common measure used in ozone **(and OMI SO_2)** research.

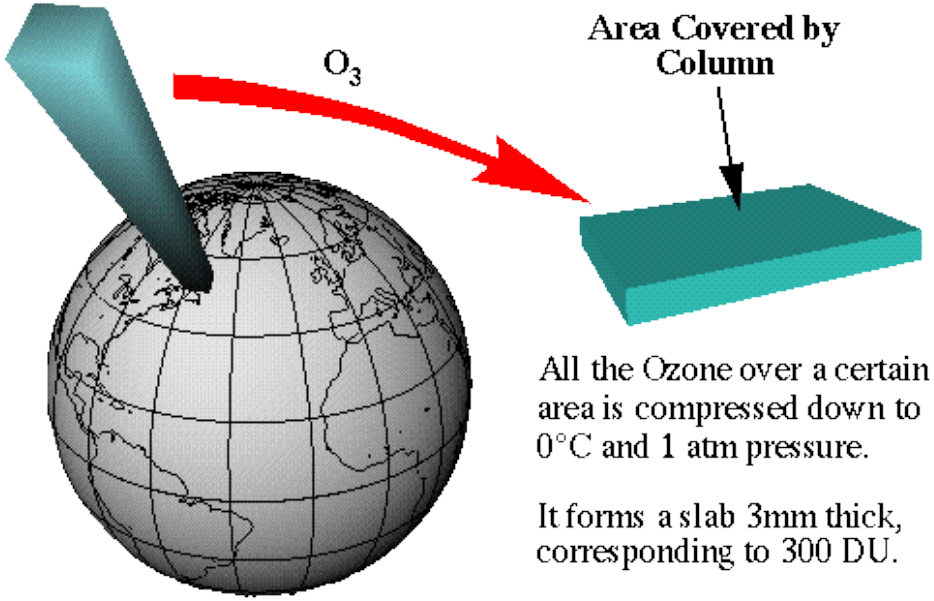
1 Dobson Unit (DU) = 0.01 mm thickness at STP (Standard Temperature (273.15 K) and Pressure (1013.25 hPa)).

1 Dobson Unit = 2.69×10^{16} molecules/cm^2

OMI SO_2 values can range from 0 DU to 10 DU (explosive volcanic eruption)

In contrast, a normal range of Ozone is 300 to 500 Dobson units, which translates to ⅛ inch - basically two stacked pennies!

G. M. B. Dobson (1889 - 1976)



Data Storage

All NASA EOS data products are processed at various levels ranging from Level 0 to Level 4. At higher levels, the data are converted into more useful parameters and formats.

Data Level	Description
Level 0	Raw data at full instrument resolution.
Level 1A	Raw data including radiometric and geometric calibration coefficients and geo-referencing parameters (e.g., platform ephemeris) computed and appended but not applied to Level 0 data.
Level 1B	Level 1A data that have been processed to sensor units (not all instruments have Level 1B source data).
Level 2	**Derived geophysical variables at the same resolution and location as Level 1 source data.**
Level 2G and 3	**Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.**
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

Another thing to consider for satellite observations

Spatial Resolution

The spatial resolution of current satellite instruments (10's of km diameter) has been shown to be good enough to map tropospheric concentration fields at local to regional scales and fine enough to resolve individual power plants or even large cities.

For those species having short atmospheric life times (e.g. NO_2), the averaging over larger satellite pixels can lead to significant dilution of signals from point sources, complicating quantitative analysis and separation of emission sources.

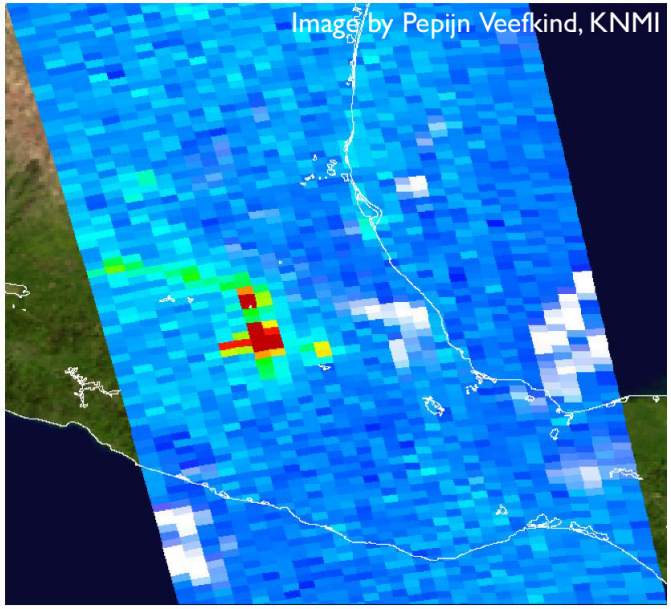
For quantitative analysis – Level 2 and high-resolution gridded Level 3 data are optimal.

Advantaged of using Level 3 vs Level 2 data are:

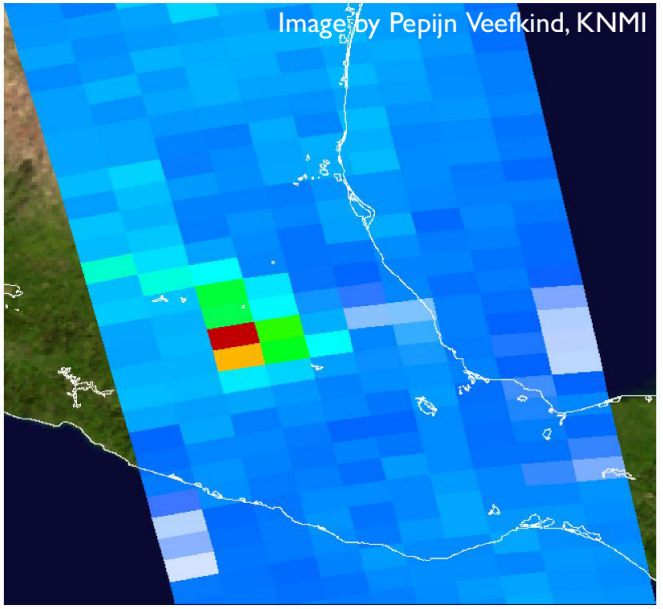
- Uniform grid
- One file per day
- Smaller sized files
- Quality flags and filtering criteria have been applied

Perspective …

Spatial Resolution

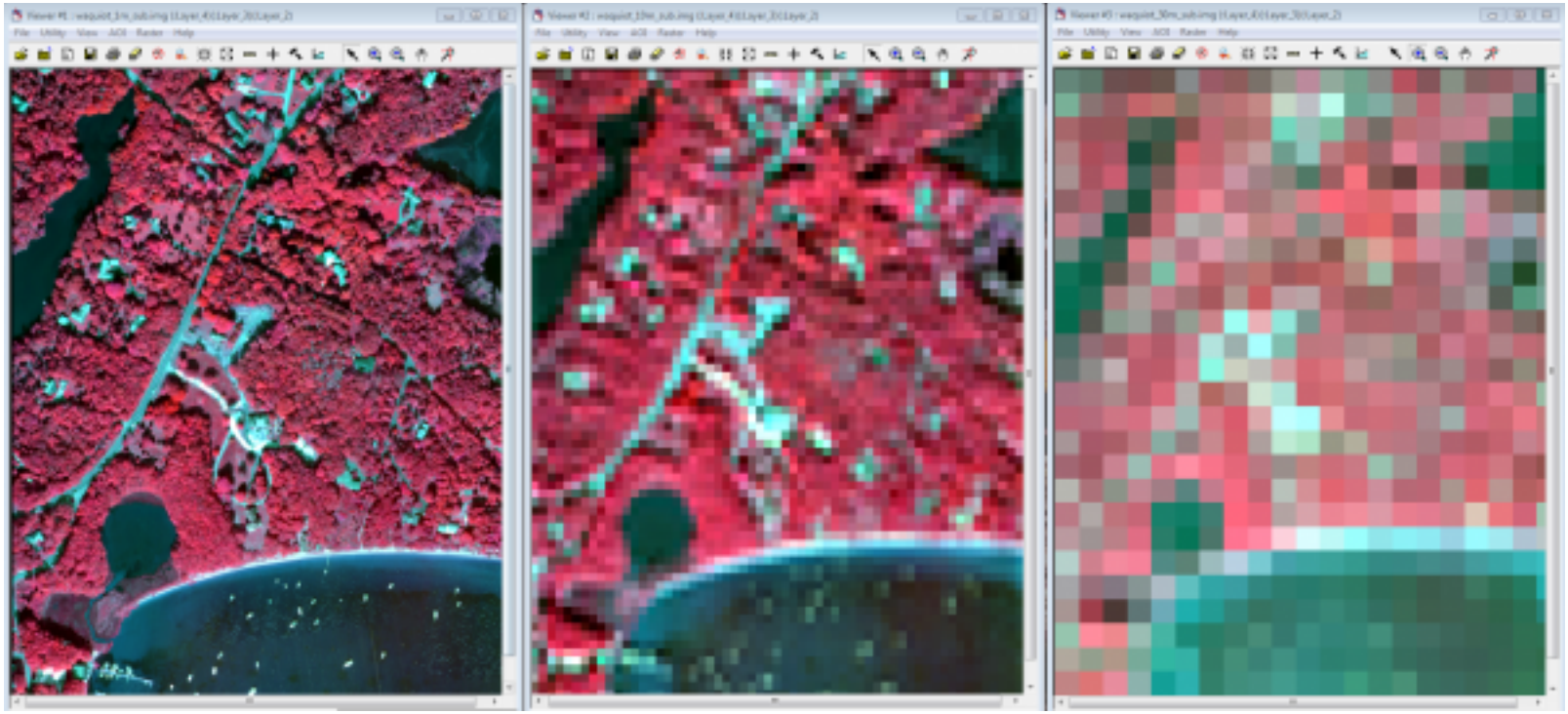


OMI 24x13 km^2



Approx. GOME-2 72x39 km^2

Mexico City, Jan. 20, 2005



File Size Increases

Waquiot Bay, MA aerial imagery in its native 1m format (left) compared to a 10m (middle) and 30m (right) version of the same data. While visual differences are easy to see, the file sizes also change from 2.5MB to 39kB to 23kB.

OMI

Ozone Monitoring Instrument

- Planetary Boundary Layer (PBL) and Volcanic SO_2

- Tropospheric Column NO_2

SO_2

- a precursor of sulfate acid (acid rain) and sulfate particle
- colorless gas with a suffocating, choking odor.
- toxic to humans
- primary from burning of coals (smelters, power plants)
- sometime from volcanic eruptions

OMI SO2 Gridded Product Summary

SO_2 Product	Level	Data Short Name	Sensitivity	Use
PBL SO_2	L3, 0.25°x0.25°	OMSO2e	0.6 km	Fossil fuel, industry
TRL SO_2	L2G, 0.25°x0.25°	OMSO2G	3 km	Industry outflow
TRM SO_2	L2G, 0.25°x0.25°	OMSO2G	5 km	optimized for volcanic degassing with vents at ~5km altitude or above and emissions from effusive eruptions.
STL SO_2	L2G, 0.25°x0.25°	OMSO2G	15 km	intended for use with explosive volcanic eruptions

Caveat: Unlike the OMSO2e 'best' product. L2G data are NOT screened for clouds, sza, quality flags, row anomalies.

OMI AQ SO_2 product in the boundary Layer

Data Set Short Name = OMSO2e

Product Level = 3

Begin Date = October 1, 2004

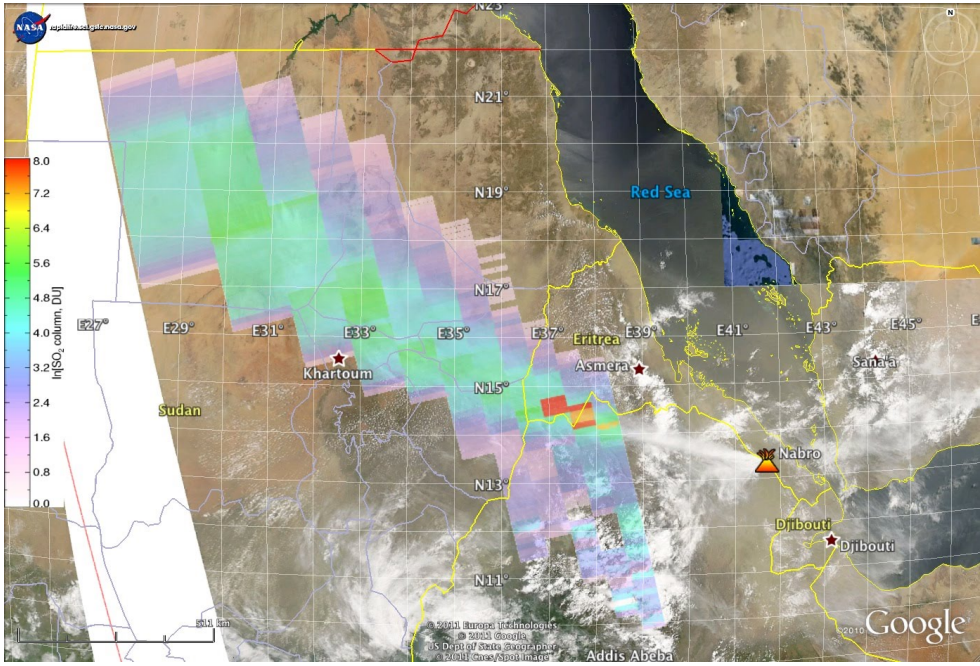
Resolution = 0.25°lon x 0.25°lat

Version = 003

Cloud-screened best measurement

Production Frequency: Daily

Granule (File) Coverage: 15 orbits
File Size(Approx): 5 MB

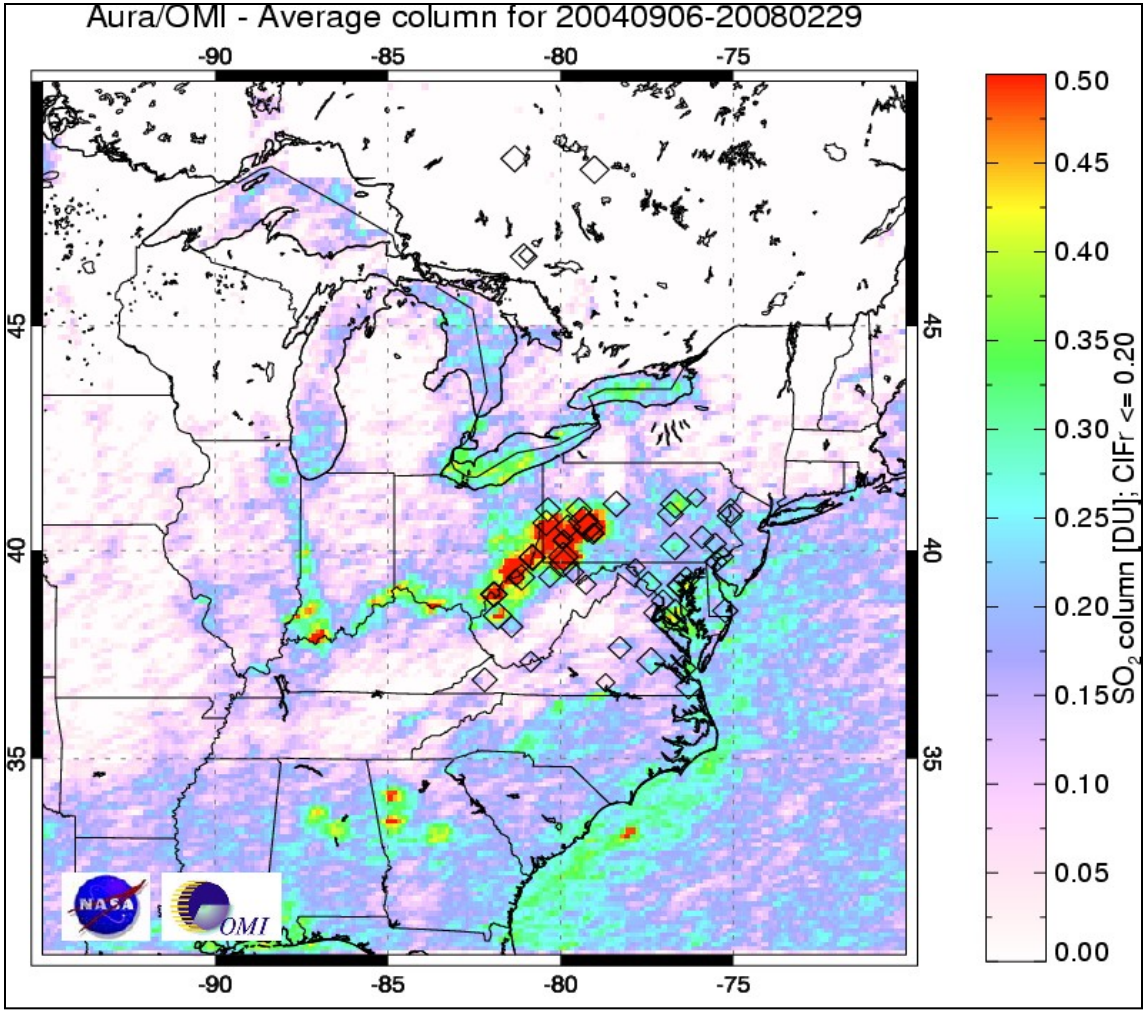


Aqua MODIS visible image of the Nabro (Eritrea) eruption on June 13, 2011 and the SO2 plume overlaid.

Contains **best** pixel data, screened for OMI row anomaly, clouds, and other data quality flags.

Data here: http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omso2e_v003.shtml

Average OMI SO_2 burdens over eastern USA



◊ - major power plants

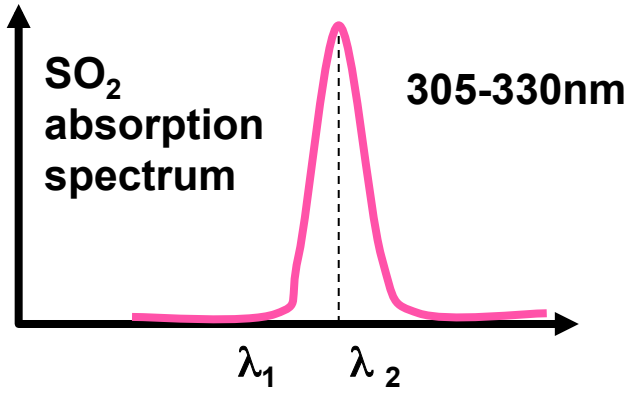
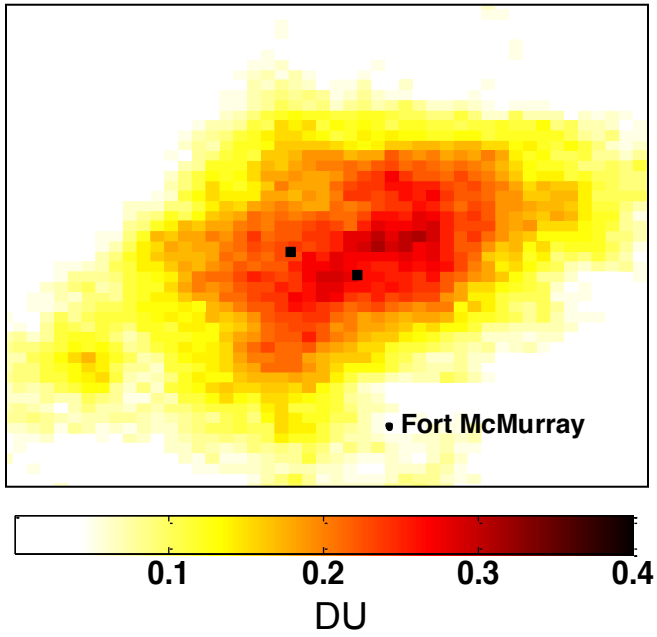


Image courtesy: Nickolay Krotkov, UMBC & NASA

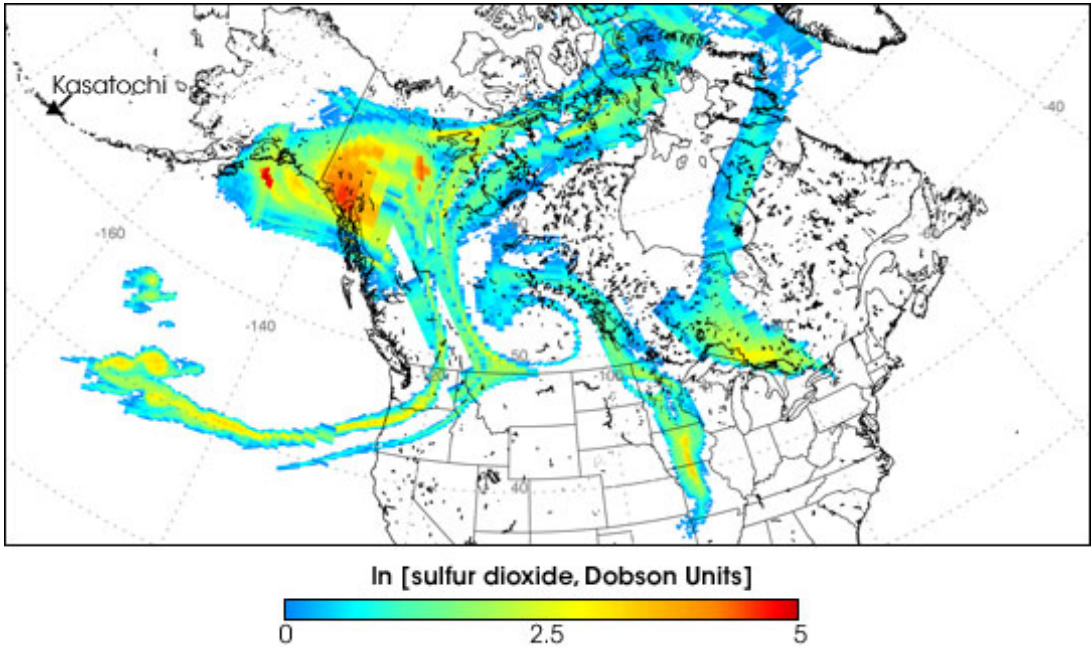
Perspective: What is considered high SO_2?

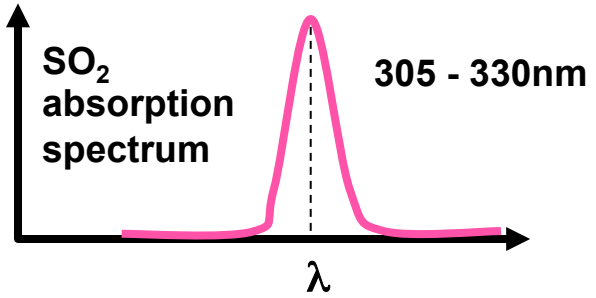
2005-2010 mean over the Canadian oil sands



McLinden, C. A., et al. (2012), Air quality over the Canadian oil sands: A first assessment using satellite observations, Geophys. Res. Lett., 39, L04804, doi:10.1029/2011GL050273.

OMI SO_2 from the Kasatochi Volcano eruption in the Alaskan Aleutian Islands on 2008 August 8 continued to spread eastward on August 12.





Data Access

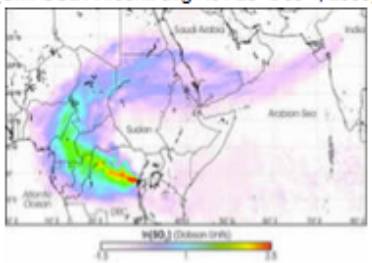
Aura OMI Sulphur Dioxide Level 3 Best Pixel Global (0.25 deg Lat/Lon grids) Data Product-OMSO2e

NEWS: OMSO2e is a Level-3 product (contains best pixel data, screened for OMI row anomaly and other data quality flags)

Data Access

• Mirador - fast search & download

SO2 Plume from Nyamuragira Volcano
(OMI SO2 Amount: avg Nov 28- Dec 4, 2006)



Principal Investigator (PI):
Nickolay A. Krotkov
(NASA GSFC)

Data Version and Data Holdings

Processing	Version	Begin Date	End Date
Forward	003	Oct 1, 2004	---

Production Frequency: 1 file/day
Granule (File) Coverage: one day
File Size(Approx): 5 MB

Platform: EOS-Aura
Instrument: OMI

Product: Level-3 OMI Sulphur Dioxide (SO2) Data Product

Data Set Short Name: OMSO2e

Data Set Long Name: OMI/Aura Sulfur Dioxide (SO2) Total Column Daily L3 Best Pixel Global 0.25deg Lat/Lon Grid

OMI Data Documents:
-Short Readme for OMSO2e
- File Format Specification
- OMI Data User's Guide

-OMI Algorithm Documents Related to OMSO2 (the data used in OMSO2e)
- OMI Algorithm Theoretical Basis Documents

Other Related Documents:
-OMSO2e Document for Global Change Master Directory
- HDF-EOS Aura File Format Guidelines

Tools:
-Data Read Software & Tools
-Giovanni Data Exploration Tool
-OMI SO2 Images (GSFC-NASA)
-OMI SO2 Images Near Real Time (NOAA)

Other Links :
-EOS-Aura OMI Page
-OMI Home Page (KNMI-Netherland)
-OMI/TOMS Home Page (GSFC-NASA)
-OMI/TOMS SO2 Page (GSFC-NASA)
-Aura Validation Data Center (AVDC)

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omso2e_v003.shtml

http://so2.gsfc.nasa.gov

NOAA Level 2, site-specific operational SO_2, cloud, and AI maps and data access.

FMI VFD SO_2 maps

NASA archived OMI daily SO_2 maps

Goddard Space Flight Center

Flight Proj

Atmospheric Chemistry and Dynamics Laboratory (Code 614)

Global Sulfur Dioxide Monitoring Home Page

Home | News | Past SO_2 images | Documentation | Publications | Personnel | Links

Volcanic Hazards Project

Latest SO_2 eruption alerts NOAA-NESDIS. SACS_BIRA. IASI-ULB.

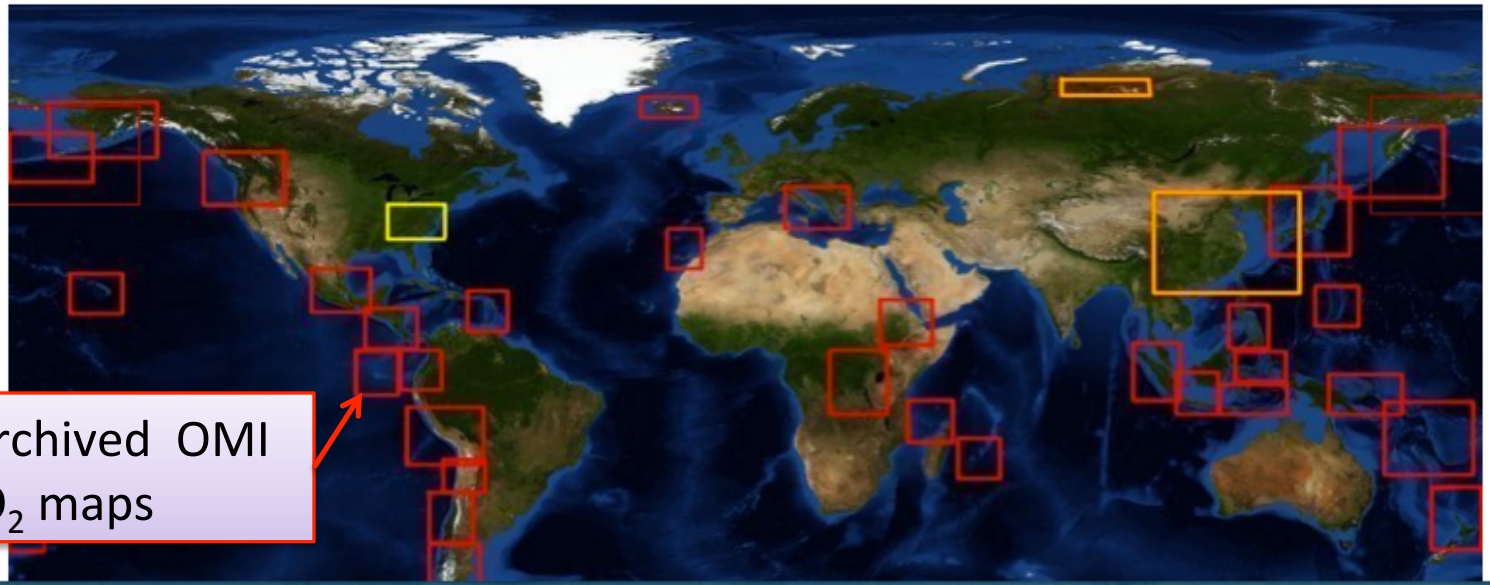
Time Images: Real-Time (15 mins). NOAA Near Real-Time (3 hours). AIRS NRT. NASA NRT. SACS-BIRA NRT.

MEaSUREs project:

TOMS images (1979-2005) | AIRS images (2003-2004) | OMI images (2004-present) | OMPS images (May 2012-present)

Latest Daily (OMI/OMPS) Images of SO_2 (click on a highlighted rectangle)

Red = daily volcanic regions, orange = daily pollution regions, yellow = long-term pollution images



OMI Very Fast Delivery Images:
http://omivfd.fmi.fi/volcanic.html

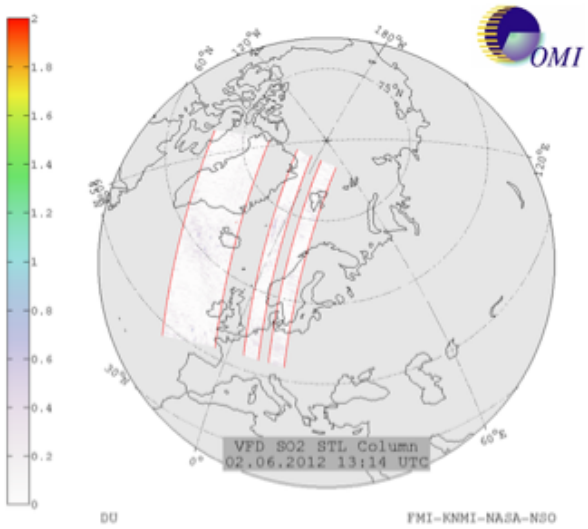
omi vfd omi very fast delivery

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

HOME | PRODUCTS | CONTACT | FAQ

volcanic products

These products can be used to monitor volcanic eruptions.



SO2	AI	CF
SO21	AI1	CF1
SO22	AI2	CF2
SO23	AI3	CF3
SO24	AI4	CF4
SO25	AI5	CF5
SO26	AI6	CF6

AI = Aerosol Index
CF = Cloud Fraction

archives

- Image search
- Info about OMI row anomaly
- Volcanic products
- Ozone products
- OMI VFD highlights

FMI
KNMI
NASA
Netherlands Space Office

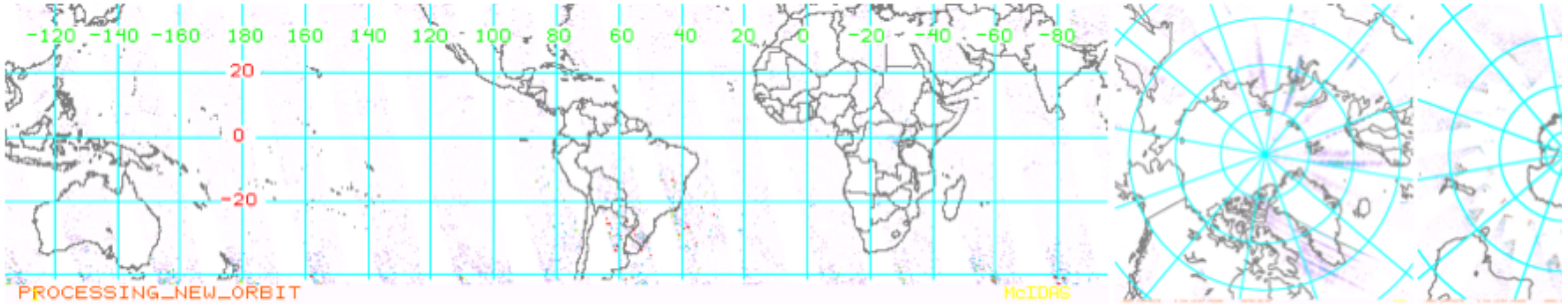
OMI near real-time SO2 interactive maps:

http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

Latest OMI SO2 Column 5Km - 24-Hour Composite Images

Important Information for OMI Data Users



Current OMI SO2 Composites	Tropics	Northern Hemisphere	Southern Hemisphere
Current & Previous Digital Images GeoTiff, NetCDF, McIDAS, GIF	Tropics	Northern Hemisphere	Southern Hemisphere

Latest OMI_SO2 Column 5Km by Volcano

Alaska, USA	Aleutian Islands, Alaska, USA	Anatahan, Mariana Islands	Cascade
Central America	Comoro Islands	Eastern China	Ecuador
Etna, Sicily, Italy	Galapagos Islands, Ecuador	Hawaii, USA	Iceland
Japan	Java, Indonesia	Kamchatka, Russia	Mexico
Montserrat, West Indies	New Zealand	North Western Europe	Northern Atlantic
Northern Chile	Nyiragongo, DR Congo	Peru	Philippines
Papua New Guinea	Red Sea	Reunion Island	Southern Chile
Sulawesi Sangihe, Indonesia	Sumatra, Indonesia	Tanzania	Vanuatu, South Pacific

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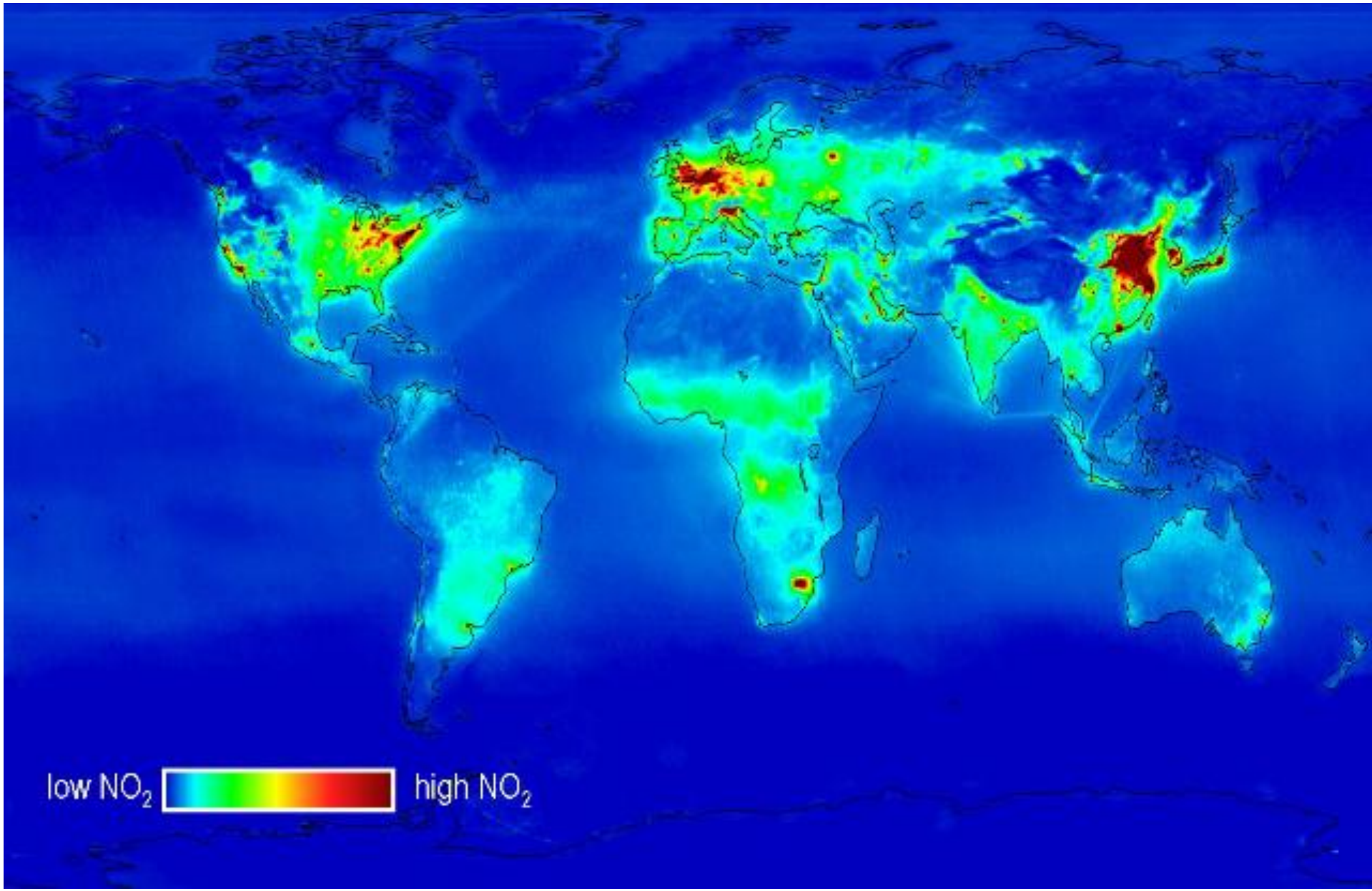
For OMI and AIRS SO2 Alerts check the OMI SO2 Alert Site and the AIRS SO2 Alert Site

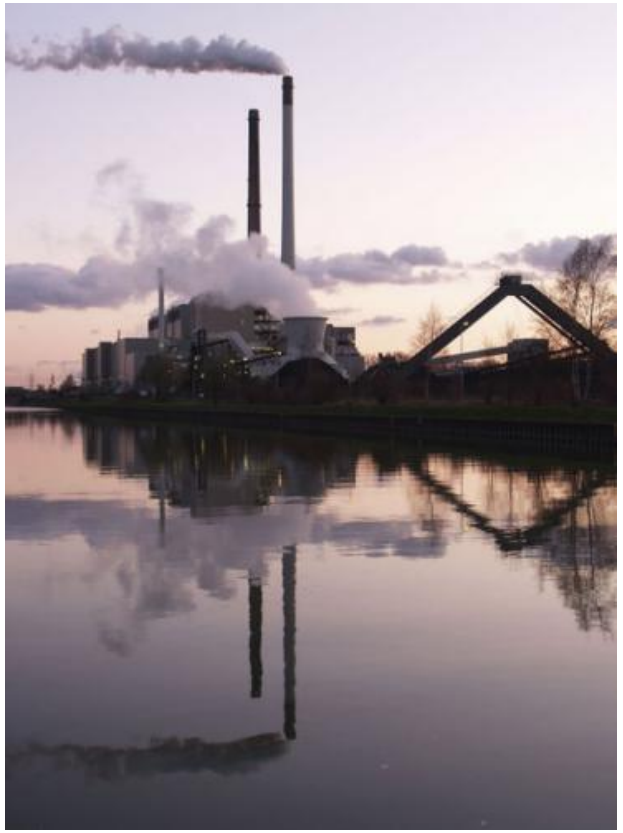
For science quality products check with NASA GES DISC and with the NASA Global Sulfur Dioxide Monitoring

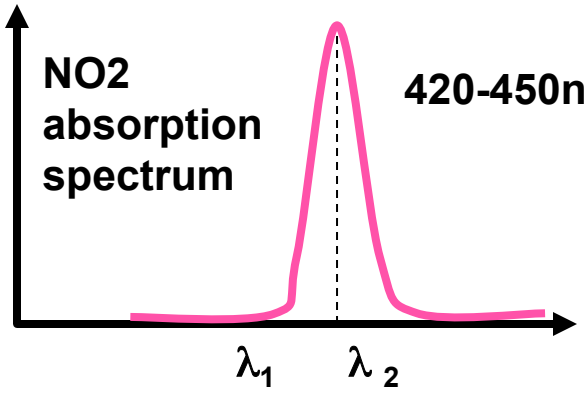
OMI NO_2 Products

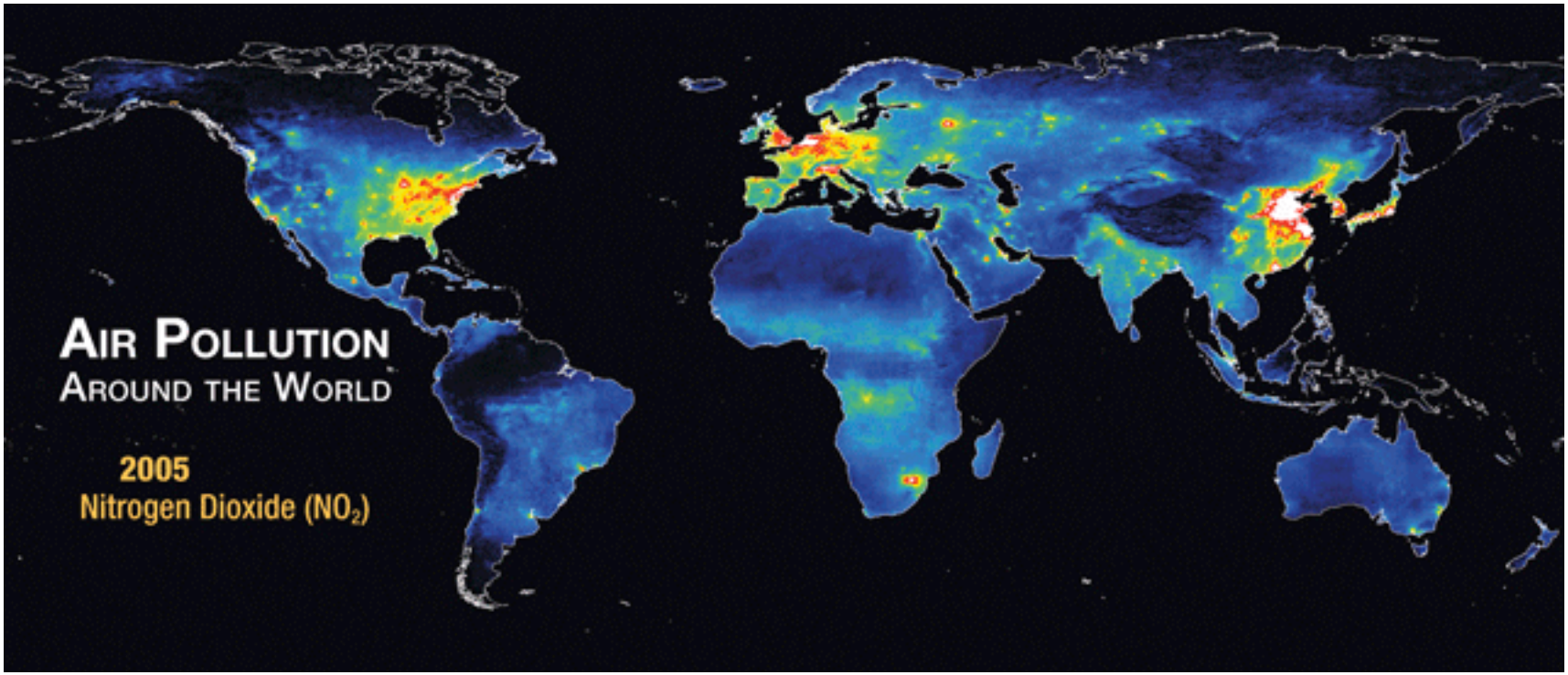


$NO_x = \mathbf{NO_2} + NO$

- NO_x + VOC → O_3 + …
- precursor of nitrate acid (causes acid rain)
- nitrate acid + ammonia → nitrate particle → particulate pollution
- toxic
- primarily from vehicle exhaust and other combustion
- most NO_X is NO_2.




NO2
absorption
spectrum
420-450nm
λ1
λ 2


AIR POLLUTION
AROUND THE WORLD
2005
Nitrogen Dioxide (NO2)

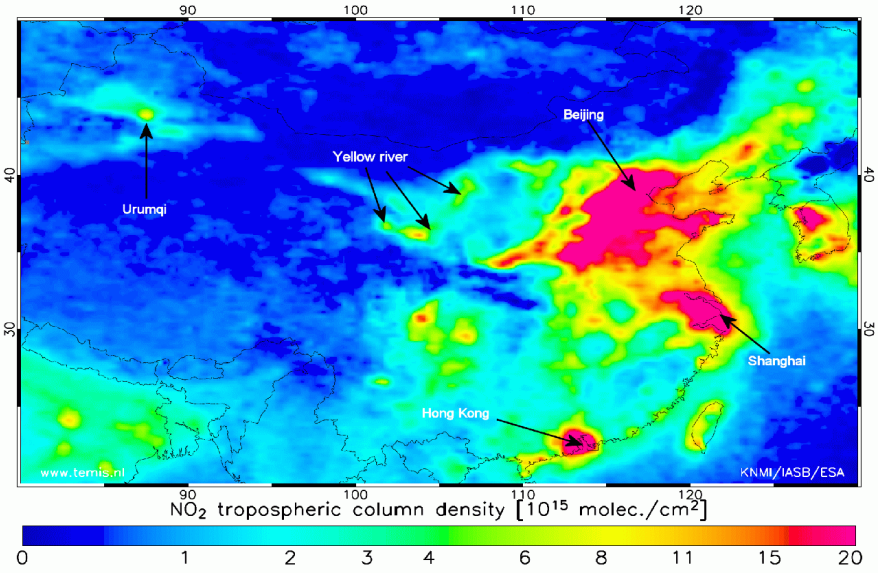
OMI Tropospheric Column NO_2 for AQ appl.

- Two *Separate* Algorithms
  1. NASA/GSFC "Standard Product"
     - Level 3 data (cloud screened) at GES-DISC and GIOVANNI
     - Data Short name = OMNO2d
  2. KNMI (Royal Netherlands Meteorological Institute) DOMINO (Near-Real Time) Product
     - Level 2 data and images available from KNMI and TEMIS.
     - Data Short Name = OMDOMINO
     - http://www.temis.nl/airpollution/no2.html
     - Includes data/images from European Satellite instruments: GOME, GOME-2, SCIAMACHY

GSFC Standard Product for AQ Applications

OMI L2, L2G and L3 products based on the enhanced algorithms has been reprocessed.

Data Set Short Name = OMNO2d
- Product Level = 3
- Begin Date = October 1, 2004
- Resolution = 0.25°lon x 0.25°lat
- Version = 003
- **Cloud-screened best observation**
- Production Frequency: Daily
- Granule (File) Coverage: 15 orbits
- File Size (Approx): 2.5 MB



Data access here:
http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml

Aura OMI Level-3 Global Gridded Total and Tropospheric NO2 Data Product (0.25x0.25 deg): OMNO2d

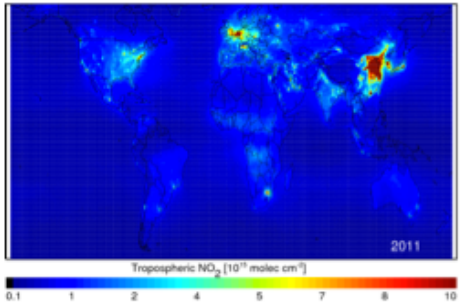
OMI Level-3 Global Gridded NO2 data product, OMNO2d, is now available from GES DISC (Release Date: Jan 10, 2013). OMNO2d data product provides the average of all good quality data in 0.25x0.25 degree global grids.

Note:
In the past, only one OMI Level-3 NO2 data product, OMNO2e, was released which contained the "average" value of all Level-2 "Good" pixels in each 0.25x0.25 deg global Level-3 grid. Recently (Jan, 2013) OMNO2e product has been replaced by new Level-3 product "OMNO2d" which is based on revised NO2 algorithm.The old OMNO2e data is no longer distributed from GES DISC. In the future, in addition to OMNO2d data, new OMNO2e product will be produced which will have only one "best" observation selected from the good quality pixels that occupy the 0.25x0.25 deg grid.

Data Access

- Mirador - fast search & download

Tropospheric Column Density of Nitrogen Dioxide, 2011



(P.I: Nickolay Krotkov, USA ; Pepijn Veefkind, KNMI)

Data Version and Data Holdings

Version	Begin Date	End Date
003	Oct 1, 2004	Current

Production Frequency: one file/day
Granule (File) Coverage: global
File Siz (max):: ~ 6 MB

Platform: EOS-Aura

Instrument: OMI

Product: Level-3 OMI NO2 Cloud-Screened Total and Tropospheric Column NO2 (V003)

Data Set Short Name: OMNO2d

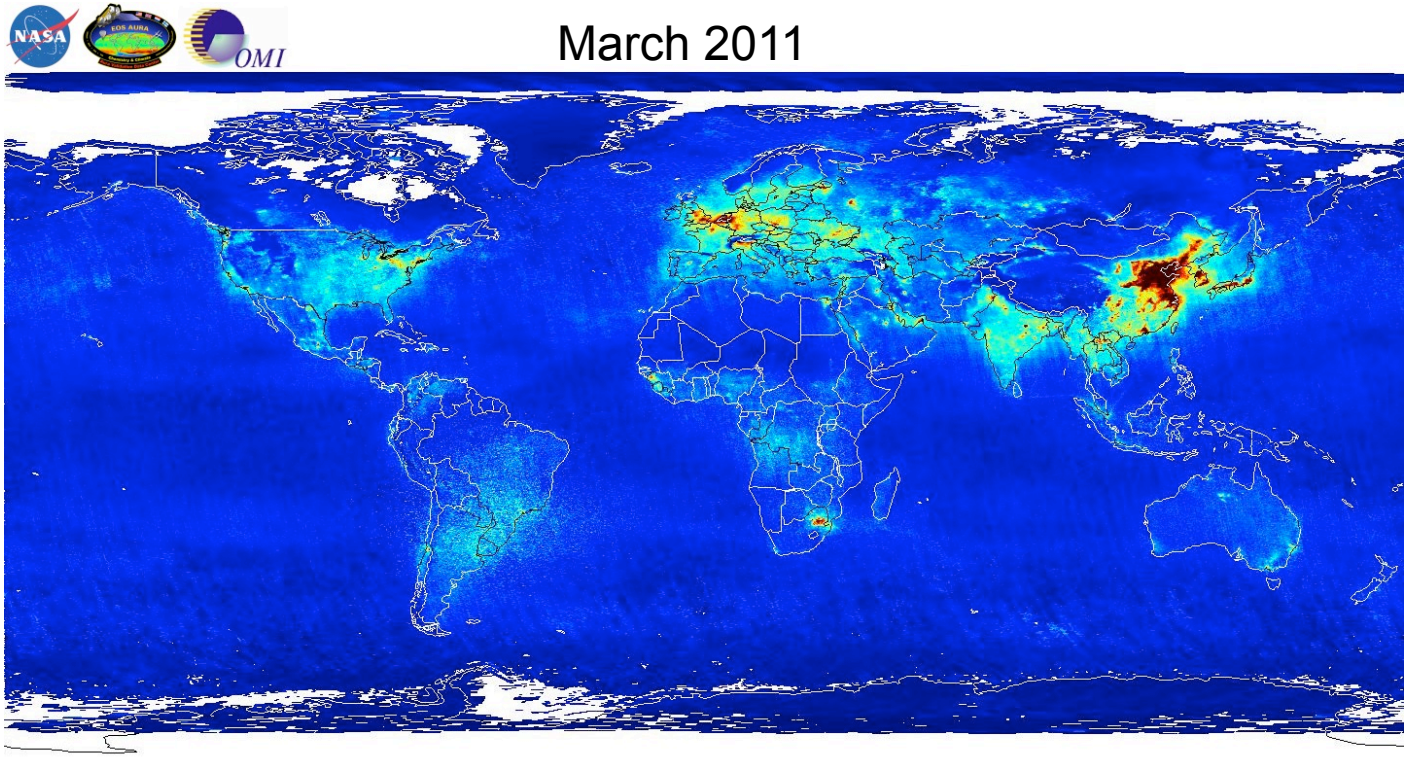
Data Set Long Name:OMI/Aura NO2 Cloud-Screened Total and Tropospheric Column Daily L3 Global 0.25deg Lat/Lon Grid (V003)

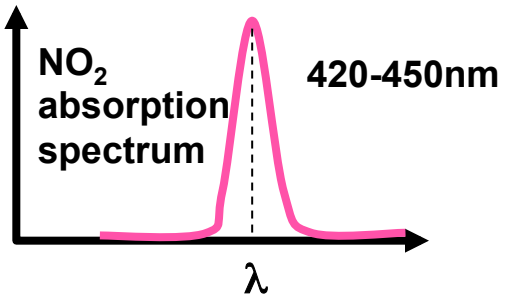
OMI Data Documents
- Readme Document for OMNO2d
- File Format Spec.
- Data Read Software & Tools
- Giovanni: Data Exploration Interface
- OMI Data User's Guide
- Algorithm Theoretical Basis Document

Other Related Documents:
- OMNO2 data document for Global Change Master Directory
- HDF-EOS Aura File Format Guidelines

Other Links :
- EOS-Aura OMI Page
- OMI Home Page (KNMI-Netherland)
- OMI/TOMS Home Page (GSFC-NASA)
- Aura Validation Data Center (AVDC)

Perspective: What is a lot of NO_2?

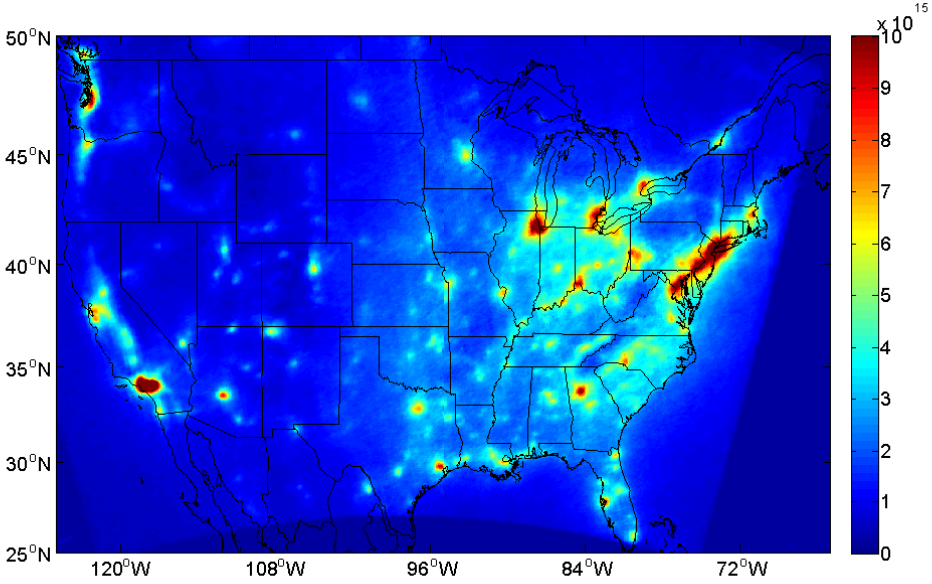




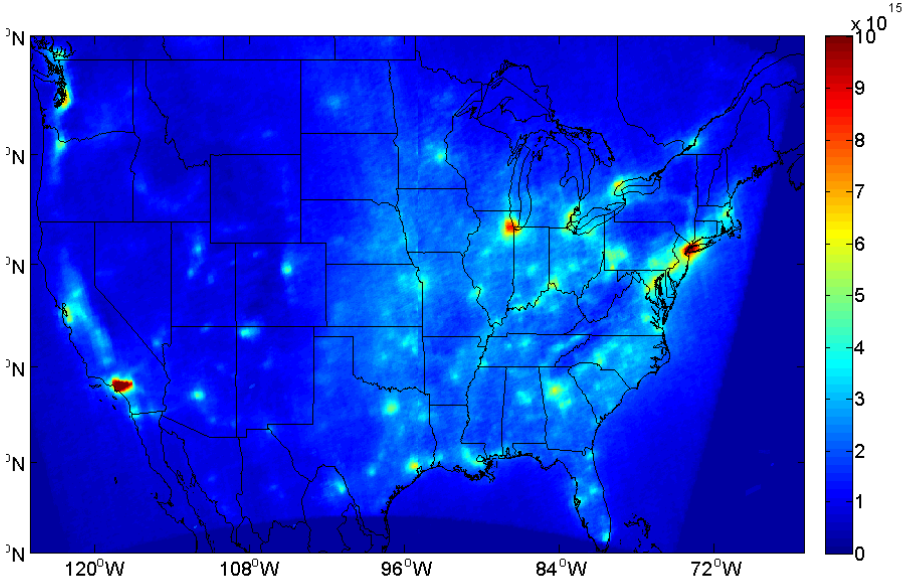
Perspective: What is a lot of NO_2?

Tropospheric Column NO_2 retrieved using the Berkeley algorithm
Credit: Ron Cohen, UCB

Summer 2005

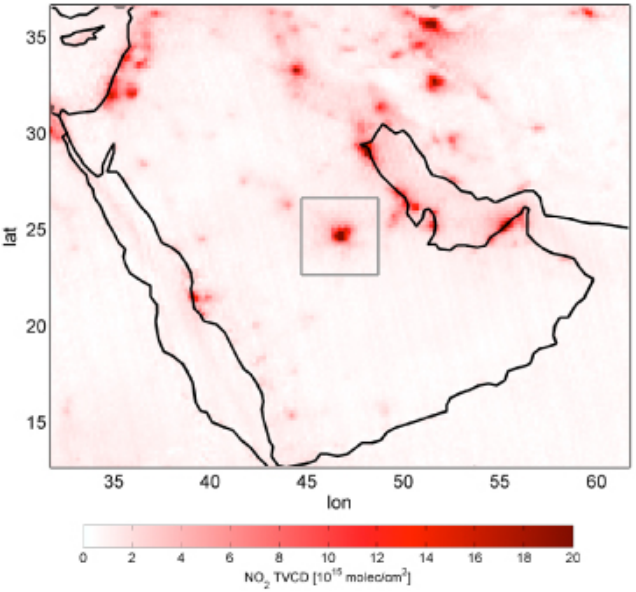


Summer 2011

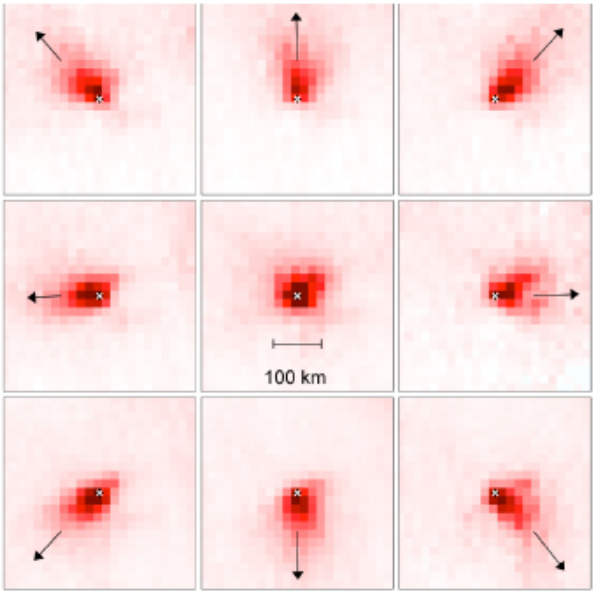


OMI DOMINO Product: Level 2 only

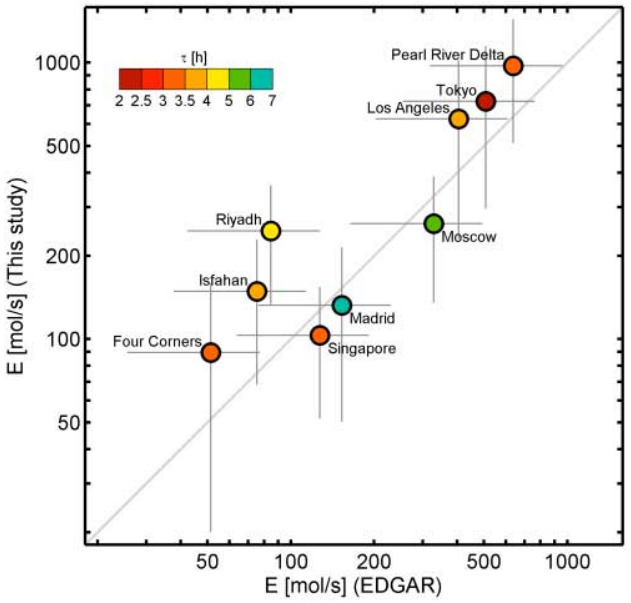
Direct observations of megacity emissions and lifetimes of nitrogen oxides



Mean NO_2 tropospheric columns in the Middle East from OMI measurements during 2005-2009 for calm (w<2 m/s) conditions.



Mean NO_2 column densities around Riyadh for different wind conditions. Arrows indicate the mean of the respective ECMWF winds.

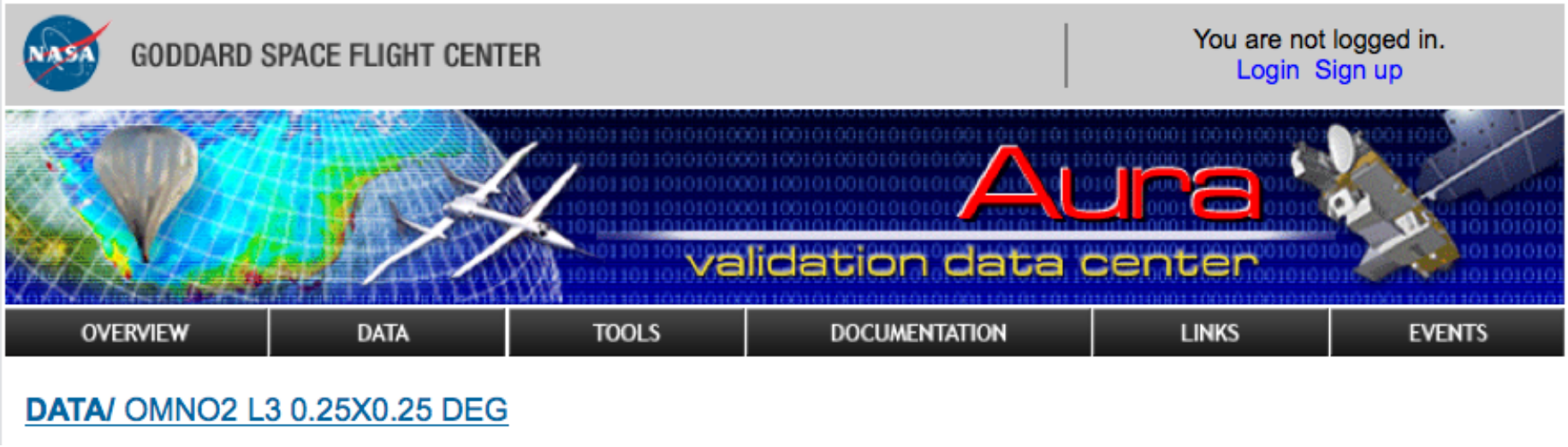


By analyzing the downwind patterns of NO_2 for different wind conditions, megacity NOx emissions and lifetimes from OMI can be determined.

Credit : Beirle et al. (2011) Science, courtesy F. Boersma (KNMI)

Access to OMI NO_2 Images and Data

AVDC - Aura Validation Data Center
http://avdc.gsfc.nasa.gov/index.php?site=705441739

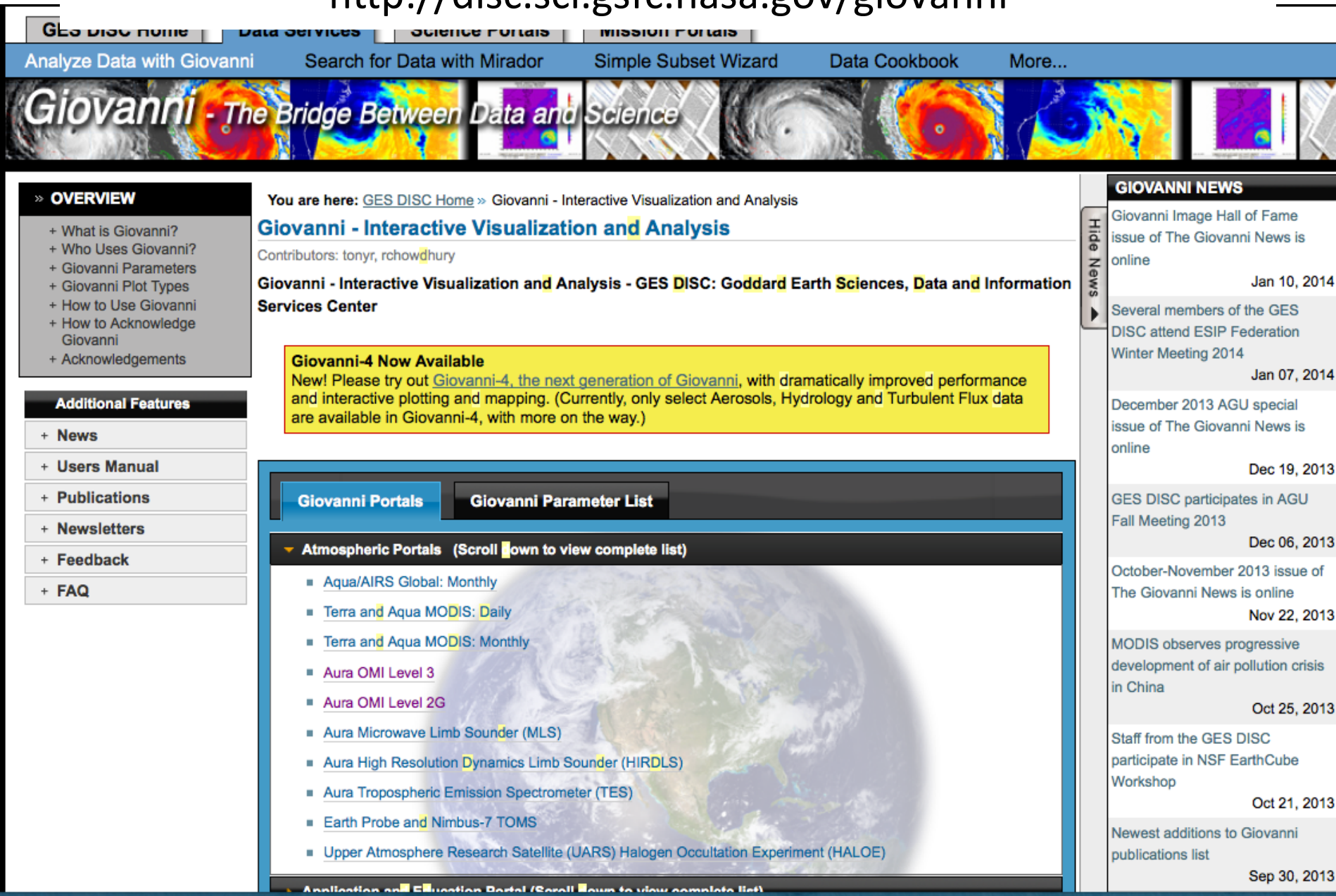


Use OMNO2d L3 product

- 0.25 Gridded, cloud screened (Reflectivity < 0.3), images and data
- Data in HDF5, ASCII, KML formats
- Daily and Monthly data/images
- Total and Tropospheric data/images

GIOVANNI – Visualization/Exploratory Tool

http://disc.sci.gsfc.nasa.gov/giovanni



GES-DISC – Goddard Earth Sciences Data and Information Services Center
http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omno2d_v003.shtml

NASA Earth Data | Data Discovery | Data Centers | Community | Science Disciplines | Search EOSDIS

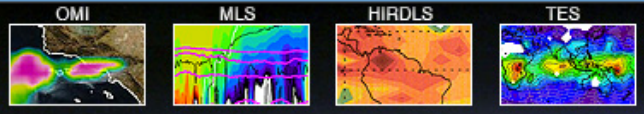
GES DISC Goddard Earth Sciences Data and Information Services Center

Search GES DISC | Search | Advanced Search

GES DISC Home | Data Services | Science Portals | Mission Portals

A-Train | AIRS | Aura | Modeling | MEaSUREs | SORCE | TRMM | More...

AURA



» DATA HOLDINGS

+ Access
» OMI
+ MLS
+ HIRDLS
+ TES

Additional Features

+ Documentation
+ Tools
+ Links
+ FAQ
+ News

You are here: GES DISC Home » Aura » Data Holdings » OMI » Aura OMI Level-3 Global Gridded Total and Tropospheric NO2 Data Product (0.25x0.25 deg): OMNO2d

Aura OMI Level-3 Global Gridded Total and Tropospheric NO2 Data Product (0.25x0.25 deg): OMNO2d

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Data Access

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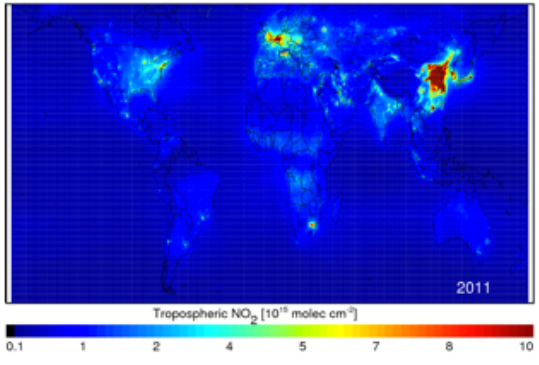
Tropospheric Column Density of Nitrogen Dioxide, 2011



Platform: EOS-Aura

Instrument: OMI

Product: Level-3 OMI NO2 Cloud-Screened Total and Tropospheric Column NO2 (V003)

Data Set Short Name: OMNO2d

Data Set Long Name:OMI/Aura NO2 Cloud-Screened Total and Tropospheric Column Daily L3 Global 0.25deg Lat/Lon Grid (V003)

OMI Data Documents

- Readme Document for OMNO2d
- File Format Spec.
- Data Read Software & Tools

TEMIS – Tropospheric Emission Monitoring Internet Service
http://www.temis.nl/airpollution/no2.html

Tropospheric NO2 from satellites

These tropospheric NO2 columns are derived from satellite observations based on slant column NO2 retrievals with the DOAS technique, and the KNMI combined modelling/retrieval/assimilation approach. The slant columns from GOME, SCIAMACHY and GOME-2 observations are derived by BIRA-IASB, the slant columns from OMI by KNMI/NASA

Tropospheric data products

Air pollution monitoring

NO_2
- global
- central Europe

CH_2O
- global

CO
- global

UV radiation

UV
- UV index
- UV dose

Ozone and related gases

Ozone
- total column
- global field
- ozone bulletin
- ozone profiles

BrO
- global field

Climate change

Aerosol
- AOD
- aerosol index

Archive (images and data)

OMI: *DOMINO version 2.0 (2004-today, de-striped until September 2013)*
individual days | monthly mean | overpass data

GOME-2 (METOP-B): *TM4NO2A version 2.3 (2013-today):*
individual days | monthly mean

GOME-2 (METOP-A): *TM4NO2A version 2.3 (2007-today):*
individual days | monthly mean | overpass data

SCIAMACHY: *TM4NO2A version 2.3 (2002-2012):*
individual days | monthly mean | overpass data

GOME: *TM4NO2A version 2.3 (1996-2003):*
individual days | monthly mean

Info on upgrade to version 2

Regional Tropospheric NO2 columns from OMI

Tropospheric NO2

NO2 observation for:

Region: World
Year: 2014
Month: February
Day: 02

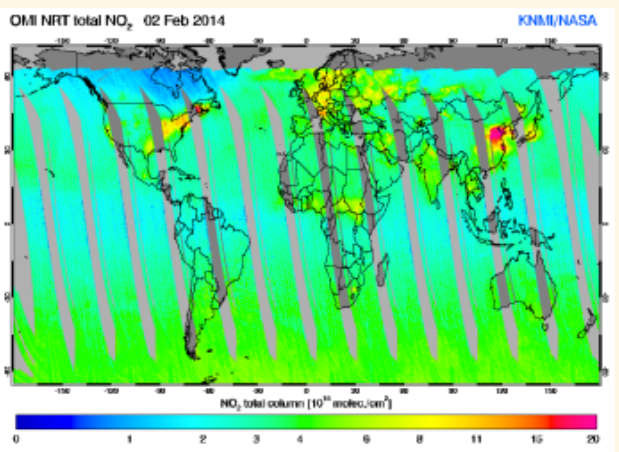
submit

Info on data anomalies

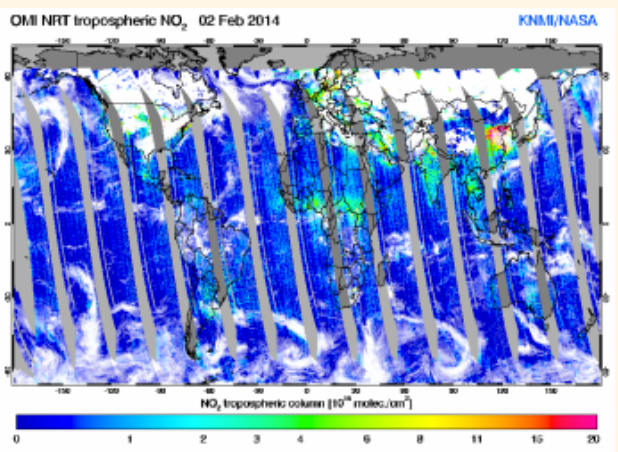
<-- previous day
<-- previous month

next day -->
next month -->

Regional NO2 of 02 February 2014



Total column



Tropospheric column

NO2 data file

Profile data is not available

Data file archive

Image in Google Earth

The End

Note: There is no assignment for this webinar.

i.e. NO HOMEWORK